**STATE BANK OF PAKISTAN**
**SBP BANKING SERVICES CORPORATION (BANK)**

# TENDER DOCUMENTS

# SECTION-V

# VOLUME – II (A)

## TECHNICAL SPECIFICATIONS

## FOR

## CONSTRUCTION OF SBP NEW OFFICE BUILDING

## AT

## GUJRANWALA

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# CIVIL WORKS

# SECTION - 0
# GENERAL REQUIREMENTS

## 0.01 GENERAL DESCRIPTION

### 0.1.01 Location of Site

The site of the project is located in Rahwali, Gujranwala, Punjab, along G.T Road.

### 0.1.02 Work Under This Contract

The work under this Contract comprises the Construction, Completion, Handing over and Maintenance of Structure, Architectural, Finishes, Building Services relating to Electrical, HVAC, BMS, Firefighting, Water Supply and Sewerage, Communication, security, site work and / or any other discipline necessary to be executed together with or incorporated in the structure works including but not limited to pipe sleeves, embedded parts, conduits, earthing pits, tube wells etc. as specified by the Contract / necessitated by the project requirements/ instructed by the Engineer.

The Contractor shall be required to plan and execute the works in a manner such that the project is completed within the time specified in the Contract and in conformity with the provisions contained in the documents of Contract. The Contractor shall furnish a detailed construction programme along with a list of plant and equipment with capacities and capabilities for the approval of the Engineer. The Contractor shall also be required to submit a site supervisory / management chart.

### 0.1.03 Execution of Work

All Work shall be executed in accordance with the requirements and in a manner set forth in the documents of Contract and in accordance with the instructions of the Engineer or Engineer's Representative. The Contractor shall confine his operations to the areas that are actually designated, for the Works, by the Employer. The Contractor shall be required to supply and maintain his own storage facilities, site office, sanitary facilities, and all temporary connections for electricity, water, sewerage and telephone etc. at his cost, subject to the approval of the Engineer.

## 0.02 APPLICABLE STANDARDS

Unless specified otherwise in the Contract Documents, all the Work and materials shall conform to the requirements of American Society for Testing Materials (ASTM) Specifications, American Concrete Institute (ACI) and British Standard Specifications (BSS) and as per the Drawings and Specifications.

## 0.03 TEST LABORATORY AND TESTING

0.03.1 Testing unless specified otherwise in the Contract, shall be performed by an approved testing agency as proposed by the Contractor and at no extra cost to the Employer. The Engineer may require all testing to be carried out under his supervision.

0.03.2 The quality control testing shall be arranged and performed by the Contractor's competent personnel in accordance with a Site Testing and Quality ControlProgramme / Facility to be established by the Contractor, and approved by the Engineer. The Contractor shall keep complete record of all the quality tests performed including the date and time of testing and submit the same to the Engineer. All quality control and related tests shall be carried out in accordance with applicable standards and codes under the supervision of the Engineer. The Contractor shall establish a laboratory on site which shall have equipment for testing Compressive Strength of concrete, Sieve Analysis and Compaction Test, as per the instructions and to the satisfaction of the Engineer.

## 0.04 STORAGE AND HANDLING FACILITY

The Employer shall assign the Contractor storage space for the storage of plant, equipment and materials for Contract Works. However the Contractor shall ensure that, on no account shall such temporary installation conflict / interfere with any of the permanent installations, services and any operational function of the Employer. The handling and storage of all plants, equipment and materials at Site shall be the responsibility of the Contractor and at no risk or cost to the Employer.

The Contractor shall protect all materials against corrosion, damage of any kind or deterioration during storage and also during erection on Site. The protection methods shall be to the approval of the Engineer.

## 0.05 TEMPORARY FACILITIES

The Contractor shall provide, erect / install, maintain, alter as and when necessary and remove on completion except as otherwise directed by the Engineer all temporary facilities and services as described hereinafter and / or in the Contract documents and / or as instructed and approved bythe Engineer, all at his own cost and expenses.

### 0.05.1 Contractor's Site Office

The Contractor's temporary site office and stores etc. including all buildings, utilities and facilities shall be available for use not later than 15 days after the date of the Site handing over.

### 0.05.2 Temporary Fencing & Lightning

The Contractor shall provide and maintain at his own cost all temporary lights, guards, fencing and watching to the approval of the Engineer for the safety and protection of the Works.

### 0.05.3 Site Sign Boards

Before manufacturing and installing sign boards at site, the Contractor shall present a design and obtain the approval of the Engineer.

### 0.05.4 Temporary Services

a. Water & Electricity

The Contractor shall make his own arrangement at his cost for water for construction, drinking and other purposes and shall also provide temporary power for the operation of construction equipment and lighting. The Contractor shall be responsible for the supply, maintenance, repair and operation of these services at his own costs throughout the construction period. The Contractor shall also provide adequate sanitary facilities for the use of his staff and Workmen and remove these services upon completion of Works at his own cost.

b. First Aid

The Contractor shall provide and maintain First Aid Facilities on the Site. First Aid kits of the type, model and number, equipped properly according to the requirements of the local health authorities and as approved by the Engineer must be furnished by the Contractor at Site.

c. Fire Fighting

The Contractor shall provide and maintain adequate firefighting facilities on the Site at his own cost to the approval of the local Fire Authority and Civil Authority and the Engineer. Firefighting equipment like fire buckets, fire extinguishers or other effective means ready for instant use shall be installed at suitable places at the project.

## 0.06 FACILITIES FOR THE ENGINEER

### 0.06.1 Supervisory Staff Site Office

a. The Contractor shall provide and maintain suitably furnished Supervisory Staff Site Office for the Engineer and his staff as per the details approved by the Engineer. The site office shall be air-conditioned and provided with ceiling fans, utilities, security, kitchen and toilet facilities. The floor area and design of the site office shall be as approved by the Engineer. This duly furnished office shall be ready for possession of the Engineer within 15 days of Receipt of Engineer's notice to commence the work.

b. It shall be provided with Office attendants, Computers, printers, photocopy machines, phones, necessary office stationary etc. as listed in the tender documents.

c. The Kitchen shall be equipped with all necessary Kitchen equipment, microwave oven and fridge.

d. Telephone and fax facilities as at (b) above shall be provided by the Contractor and all the installation and running costs shall be deemed to be included in the rates of the Contractor.

e. The Contractor shall provide and would be responsible for the daily cleaning, as well as the running and maintenance of the site office including, electricity supply, water, sewerage disposal etc.

f. The Site Office shall be removed from the site when the project is complete, leaving the site neat and clean and/or all as required by the Engineer. The cost on this account shall be deemed to be included in the unit rates of the Contractor.

### 0.06.2 Supervisory Staff Transport

The Contractor shall provide new air conditioned vehicles as listed in the tender document along with drivers for the use of the Engineer and his staff till the completion of the project. The Contractor shall be responsible for all the running and maintenance costs of the said vehicles. No separate payment shall be allowed on this account and all such costs shall be deemed included in the unit rates of the Contractor. All maintenance and repair works during the currency of the project shall be carried out promptly by the Contractor failing which all such works shall be got done by the Engineer at the cost of the Contractor.

## 0.07 PROJECT RECORD DOCUMENTS

The Contractor will submit shop drawings showing work sequence, work methodology, including location of construction joints, pouring sequences for the approval of Engineer prior to start of work on each stage of the project or at any time if requested by the Engineer.

The Contractor will maintain complete, accurate log of all construction work as it progresses through recording progress on the approved work plan, progress reports and construction photographs stage wise.

The Contractor will submit weekly and monthly progress reports to the engineer, on approved format with photographs.

On completion of foundation, retaining walls and other major construction milestones, prepare certified As-built drawing showing work done, dimensions, locations, angles and elevations of construction and site work.

## 0.08 MEASUREMENTS AND PAYMENT

No separate payment shall be made for the services and performance provided under this section of Specifications.

The Contractor is deemed to have covered the costs of all related supplies and performance in the unit prices of other contract items.

**** END OF SECTION****

## SECTION - 1

## CLEARING, GRUBBING & SETTING OUT OF WORKS

### 1.01 SCOPE OF WORK

The Work covered by this section of Specifications consists of furnishing all labour, materials, necessary equipment, services, miscellaneous and necessary items, required to satisfactorily complete the clearing, grubbing and setting out of the Works, as indicated on Drawings, specified herein and subject to the terms and conditions of the Contract.

### 1.02 CLEARING

Clearing shall consist of cutting up or trimming of trees, if any, and the satisfactory disposal of trees and other vegetation designated for removal, together with the down timber, snags, bushes, and rubbish occurring within the areas to be cleared. Trees, other vegetation, stumps, roots, and bushes in areas to be clear shall be cut-off below the original ground to extract the roots except such individual trees, groups of trees and vegetation as may be indicated on the Drawings or designated by the Engineer to be left standing. Individual trees, groups of trees, and other vegetation, to be standing, shall be thoroughly protected from damage incident to construction operations by the erection of barriers or by such other means as the circumstances required, and as approved by the Engineer. Clearing operations shall be conducted so as not to cause any damage or harm to existing structures and installations and to those under construction, and so as to provide for the safety of employees and others.

### 1.03 GRUBBING

Grubbing shall consist of the removal and disposal of all occurring stumps, roots larger than 38 mm in diameter, matted roots in the designated grubbing areas, stumps, roots, logs or other timber more than 38 mm in diameter, matted roots and other debris shall be excavated and removed to a depth not less than 450 mm below any subgrade, shoulder or slope. In areas wherethe cut is over 1.0m, grubbing shall not be necessary. In areas to be paved, or in areas indicatedon the Drawings or designated by the Engineer as future paved areas where excess excavation from grading operations is placed, grubbing will be necessary.

### 1.04 DISPOSAL

Unless directed otherwise, timber and other refuse shall be disposed of by burning at locations approved by the Engineer in a manner that will avoid all hazards such as damage to existing structures, construction in progress, trees and vegetation's. The Contractor shall be responsible for compliance with all pertinent laws and regulations pertaining to the burning of fires and observance of any security regulations applicable thereto.

Disposal by burning shall be kept under constant attendance until the fires have burned out or have been extinguished. No materials will be permitted to be pushed or placed on adjacent property without prior written approval of the owner of such property.

### 1.05 SETTING OUT OF WORKS

The Contractor shall set out the Works and shall be responsible for true and perfect levels and setting out of the same and for correctness of the direction, positions, levels, dimensions and alignments of all parts thereof. If any error in this respect shall appear during the progress of the Work, the Contractor shall at his own expense rectify such error to the satisfaction of the Engineer. Any checking by the Engineer shall not relieve the Contractor from his complete unshared responsibility for correct setting out of Works. The Contractor shall construct and maintain accurate bench marks so that the lines and levels can be easily checked by the Engineer.

## 1.06 DRAINAGE DITCHES / DEWATERING

The Contractor shall construct and maintain such ditches / drains in addition to those shown on Drawings or as may be ordered by the Engineer to adequately drain the areas under construction of the water from any source including subsoil water in foundations. If due to any negligence the area is flooded the same shall be drained with adequate measures by the Contractor at his owncost.

## 1.07 MEASUREMENT AND PAYMENT

The quantities for grubbing, clearing, disposal and protection works shall be taken into account on lump sum basis and payment shall be made accordingly at the rate entered in the Bill of Quantities.

No separate payment shall be made for setting out of Works. The Contractor shall be deemed to cover the costs for this item of work in the unit price of other Contract items.

Disposal of surplus material beyond initial 1000m lead.

**** END OF SECTION****

## SECTION - 2
## EXCAVATION AND BACKFILLING

### 2.01 SCOPE OF WORK

The Work covered by this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with excavation, de-watering, filling, back-filling, stock piling of suitable excavated material and disposal of all surplus and unsuitable material for construction works and foundations for structure & services line trenches, complete, in strict accordance with this section of the Specifications and the applicable Drawings and subject to the terms and conditions of the Contract and as per existing laws imposed by the local authorities.

### 2.02 SUB-SOIL CONDITIONS

2.02.1 The Contractor shall acquaint himself with the nature of the ground, existing structures, foundations and subsoil conditions, which might be encountered during excavation or earthworks on the Site and his bid shall be fully covering the works involved. The Employer does not guarantee or warrant in any way that the materials to be found in the excavation will be similar in nature to that of any samples which may have been exhibited or indicated in the Geotechnical Report, Drawings or in any other Contract Documents or to material obtained from boring or trial holes.

2.02.2 The Contractor shall make his own deductions for sub-surface conditions which may affect methods or cost of constructions of the work hereunder and he shall make no claim whatsoever for damages or compensation, should he find conditions during the progress of the Work, different from those as calculated and/or anticipated by him.

2.02.3 The Contractor shall be deemed to have made local and independent inquiries as to and shall take the whole risk of the nature of the ground, subsoil or material to be excavated or penetrated and the Contractor shall not be entitled to receive any extra or additional payment nor to be relieved from any of his obligations by reasons of the nature of such ground, subsoil or material.

### 2.03 EXCAVATION

2.03.1 The Contractor shall perform a joint survey with the Engineer's Representative, of the area where earthwork is required, plot the ground levels on the drawings and obtain approval from the Engineer before starting the earthwork.

2.03.2 Excavation shall include the removal of all material of every name and nature. If rock or concrete is encountered, it should be removed carefully and without excessive noise and vibration. Use of explosives shall not be permitted and no extra rates or any payment in such a case shall be made to the Contractor.

2.03.3 The Contractor shall give reasonable notice to commence any excavation and he shall submit to the Engineer full details of his proposals. If the Engineer may require modifications to be made in the Contractor's proposals, the Contractor shall give effect to such modifications but shall not be relieved of his responsibility with respect to such work.

2.03.4 For major excavations, the Contractor shall submit for the prior approval of the Engineer full details and Drawings showing the proposed method and procedure for supporting and strutting, dewatering and maintenance of adjacent structures. The design, provision, installation, erection, maintenance and removal of such temporary works shall be the responsibility of the Contractor and all costs in these respects shall be deemed to be included in the rates quoted by the Contractor.

2.03.5 The Contractor's attention is drawn particularly to his obligations under the General Conditions of Contract in respect of those works which are in close proximity to existing buildings/structures.

2.03.6 The Contractor, if he deems necessary, for large excavations in soil including soft rock, can use excavators, caterpillars, backhoes and/or other excavating machinery as approved by the Engineer, to facilitate efficient operations on site.

2.03.7 The excavation shall conform to the dimensions and elevations as indicated on the Drawings or as directed by the Engineer. Foundations on made up ground shall have to be taken down to natural bottom soil as per Drawings, direction and approval of the Engineer.

2.03.8 Excavation shall extend to a sufficient distance from wall and footings to allow for placing and removal of forms, installation of services and for inspection but the same shall not be paid separately and is deemed to be included in the unit rates of the Contractor.

2.03.9 In the event of any excavations being carried out deeper than required/specified levels, the same shall be filled in by the Contractor at his own cost to the required levels with lean concrete 1:3:6 under the footings and foundation slabs as per the instructions of the Engineer.

2.03.10 In the event of any excavations being carried out wider than the required/specified dimensions, the same shall be filled in by the Contractor at his own cost to the required levels with properly compacted well graded sand free from any deleterious substance as per directions of the Engineer.

2.03.11 No excavation shall be back-filled nor any Permanent Work commenced until the foundation has been inspected by the Engineer and his permission to proceed given.

2.03.12 In case, any excavation is carried out and the pits and trenches, are filled with accumulated sand or debris from blowing windstorm, dust-storms, moving sand dunes or by any other reasons thereof after the levels were checked by Engineer, then the excavation or leveling shall have to be carried out again in the same manner as before unless and until concreting is done in the foundation/trenches. No separate payment shall be made on any such accounts.

2.03.13 The Contractor shall construct and maintain such ditches, in addition to those shown on the plans, as will adequately drain areas under construction.

## 2.04 SHORING AND BRACING

The Contractor shall provide at his own cost, where required, all shoring, bracing, walls, supports etc. to the sides of the excavation to prevent sliding or any movement. Where necessary, excavated sides shall be sloped as directed by the Engineer with no extra cost to the Employer.

Shoring including sheet piling, where required during excavation, shall be installed to protect workmen and the banks, adjacent, structures, paving and utilities. The term shoring shall also be deemed to cover whatever methods the Contractor selects to adopt with prior approval of the Engineer, for upholding the sides of excavation against the side of public roadways and adjoining properties in existing hardcore or any other material. The Contractor will be held responsible for upholding the sides of all excavations and no claim for additional excavation, concrete or other material will be considered in this respect and shall be deemed to be included in his rates.

## 2.05 DEWATERING AND DRAINAGE

If water is met with in the excavations due to springs, seepage, rain or any other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry at all times. Care shall be taken to discharge the drained water into suitable outlets as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the contractor, if any such damage is caused, it shall be the sole responsibility of the contractor to repair/restore to the original condition at his own cost or compensate for the damage.

The Contractor shall control at his own cost all the grading in the vicinity of the Site of Work in order to prevent any water from running into the excavated areas.

The Contractor shall, at his own cost, keep bone dry all pits and trenches during construction and all dewatering and pumping out whether due to ground water seepage or otherwise shall be included in the rates as quoted by the Contractor. The method employed in all cases shall be approved and agreed by the Engineer.

## 2.06 PROTECTION OF UTILITY LINES

When any existing utility lines whether to be retained or to be removed are encountered within the area of operations, the Contractor shall notify the Employer/Engineer, and shall not proceed until necessary measures are taken for protection or removal of the lines and instructions are obtained from the Engineer/Employer. This will be done at no extra cost to the Employer.

## 2.07 FILL AND BACKFILL

2.07.1 After completion of foundations, footings, walls, slabs and other construction below the elevation of the final grades and prior to backfilling, forms shall be removed and excavation shall be cleaned of trash and debris. No backfilling shall be done until the entire foundations and footings etc. have been cured, inspected, approved and measured by the Engineer. Backfill shall be placed in horizontal layers not more than 6‖ thick and shall have a proper moisture content for the required degree of compaction of 95%. Each layer shall be compacted by mechanical tampers or by other suitable equipment approved by the Engineer. Backfill shall be brought to a suitable elevation above grade to provide for anticipated settlement and shrinkage thereof.

2.07.2 Where concrete slabs, floors and pavements are to be placed on the ground, any loam, organic and other unsuitable materials shall be removed.

2.07.3 Filling shall consist of approved selected material from excavation or approved granular material, free from lumps, debris, rubbish, wood, organic or other unsuitable matter and capable of compaction by approved means.

Fill, where required to raise the sub-grade for concrete slabs, shall be clean unadulterated earth, free from deleterious and organic substances and shall also be free from wood, stones and other debris. In case, sand shall be provided for filling, the same shall be clean and free from harmful substances.

2.07.4 All materials, when used in fill shall be compacted to 95% modified AASHTO density by power roller, mechanical rammer, or other approved equipment, in layers not more than 6‖ thick. In sand filling, each layer shall be uniformly spread, saturated with water or dried and then compacted. The Contractor shall arrange at his own cost the testing of the filling.

2.07.5 Backfill shall not be placed against foundation walls etc. before 14 days and not prior to the damp proofing /water proofing treatment as specified elsewhere in these documents. Backfills shall be brought up evenly on each side of structures as far as

practicable. Heavy equipment for spreading and compacting backfill shall not be operated closer to the structures less than the distance equal to the height of the backfill above the top of footing.

2.07.6 The filling material shall be subject to the approval of the Engineer and shall conform to AASHTO Soil Classification System.

2.07.7 Filling around pipes and cables shall be carried out carefully by placing fine material to cover the pipe or cable completely before the normal filling is placed.

## 2.08 COMPACTION

Fill and/or backfill within the building or wherever required within the premises shall be compacted to a density of not less than 95% of the maximum density at optimum moisture content.

## 2.09 ROUGH GRADING

2.09.1 Necessary rough grading shall be carried out by the Contractor to establish the finish grade or construction requirements of the Site, grades not otherwise indicated shall be uniform levels or slopes between points on existing and finished grades. Abrupt changes in slopes shall be rounded. Additional fill required to complete rough grading shall be provided as directed by the Engineer.

2.09.2 Where pavings or slabs are specified, all rough grading shall be done to the sub-grade of the base course, removing all large stones and debris and shall be compacted uniformly to the correct lines and levels ready to receive the paving or slab. Refilling, where required shall be executed with suitable selected materials in layers not exceeding 6‖ in thickness and thoroughly compacted to the required density.

## 2.10 BOTTOM ELEVATIONS OF FOOTINGS/FOUNDATIONS

The elevations as noted in the Drawings are only approximate and must be adjusted in the field with the approval of the Engineer depending on the soil conditions encountered. No concreting shall begin until the design soil bearing capacity is substantiated by visual inspection by the Engineer. Where suitable foundation material is found lower than the underside of footings as detailed, the space between the founding material and footing soffit shall be backfilled with well compacted gravel/soling. Where soling is provided below the foundations, it shall be well compacted and the interspaces shall be properly filled with lean concrete.

The Contractor in planning his work shall make arrangements and provision to construct the lowest level footing first.

## 2.11 DISPOSAL OF SURPLUS EARTH AND RUBBISH

All surplus earth, unsuitable material and rubbish shall be disposed of the Site as directed by the Engineer. The term disposal shall include all operations of loading, unloading, stacking, spreading, re-handling, filling depressions, leveling and grading as per instructions of the Engineer. The maximum limit for disposal of surplus material shall be 18 miles.

## 2.12 SAND FILLING IN TRENCHES AND/OR UNDER FLOORS

Sand filling shall be done in layers not more than 4‖ (100 mm) thick and shall be rammed after saturation to such an extent that 4‖ (100 mm) layer is reduced to about 2.7‖ (68 mm) after compaction.

The required in situ density w.r.t. maximum density to optimum moisture content shall be in compliance with test 12 of B.S 1377-1967.

The base shall be perfectly level. A slope of 1:64 shall be provided in verandahs and bathrooms

is required.

Sand shall conform in all respect to the specifications for fine aggregate except for its grading, i.e. shall pass through a Sieve No. 16 and not more than 30% shall pass through a Sieve No. 100.

## 2.13 GRAVEL LAYER UNDER FOOTINGS

A gravel layer, as shown in drawings, will be provided below footings/ rafts as a drainage layer. It shall conform to conditions set out in Section 29 of this specification.

## 2.14 HARD ROCK EXCAVATION

Rock excavation shall include removal and disposal of the following: (1) all boulders measuring 1/3 of a cubic yard or more in volume; (2) all rock material in ledges, bedding deposits, and un-stratified masses which cannot be removed without systematic drilling and blasting; (3) concrete or masonry structures which have been abandoned; and (4) conglomerate deposits which are so firmly cemented that they possess the characteristics of solid rock and which cannot be removed without systematic drilling and blasting. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations. No tree roots over 2 inches in diameter shall be cut without express permission of the ENGINEER. Trees shall be supported during excavation by any means previously reviewed by the ENGINEER.

It is expected that nearly all excavation can be accomplished using conventional equipment.

a. For general excavation, a D-9N Caterpillar tractor with a single shank ripper, or equivalent equipment, is considered conventional equipment, if it can rip at a production rate of at least 300 bank cubic yards per hour.

b. For trench excavation, a 235C Caterpillar excavator with a medium stick and a rock ripping bucket, or equivalent equipment, is considered conventional equipment, if it can excavate at a production rate of at least 30 bank cubic yards per hour.

If material is encountered which the Contractor believes cannot be excavated by conventional equipment, the Engineer shall be immediately notified.

The Contractor shall provide performance tests of the specified conventional or equivalent equipment. If the Engineer confirms in writing that the specified conventional equipment cannot perform at the production rates specified, the excavation shall be considered rock excavation.

In areas to be later rip-rapped, large rock found during excavation of the stream channel may, upon approval of the Engineer, be left in place, excavated around and incorporated into the final riprap.

Should the Contractor encounter bedrock or excessive large boulders within the project site, which will require extensive excavation to achieve final grade, the Contractor shall immediately notify the Engineer. The Engineer shall review the hydraulic requirements of the stream in the affected area in a timely manner and advise the Contractor on acceptable alternate excavation.

The Contractor shall adopt a method of working such that at any time, control perimeter blasting operations including the drilling of perimeter holes do not advance by more than one panel ahead of bulk blasting operations and more than two panels ahead of mucking operations to remove all blasted materials to the perimeter face, unless specially approved by the Engineer, in order that adjustments to drilling, charging and detonation can be made, appropriate to the conditions being encountered.

Rock on the cut face that is loose, hanging, or creates a potentially dangerous situation during or upon completion of the excavation in each lift shall be removed or stabilized. No drilling for the next lift shall be carried out until this work is completed. Stabilization shall be performed at

Contractors' own expense if caused by the Contractor's blasting operations.

Slopes of cuttings formed in rock are to be cleaned of all rock fragments which move when pressed with a crowbar.

**Explosives and Blasting**

It is not anticipated that blasting will be required for this project. Should the Contractor exhaust conventional equipment and methods for rock excavation and removal and desire to use explosives to accomplish this work, it shall comply with the following:

a. Blasting and storage and handling of explosives shall be in accordance with the Construction Safety Orders of the Division of Industrial Safety of the California Department of Industrial Relations, Federal Safety Requirements, the San Mateo County Sheriff, and other authorities which have jurisdiction.

b. The Contractor shall obtain all necessary permits and furnish copies to the Engineer before explosives are transported to the site. The Contractor shall pay for permits at no additional cost to the Owner.

c. Blasting shall be done only by skilled operators under the direction of a licensed foreman.

d. The Contractor shall identify all property, structures, and persons which may be affected by blasting and shall take all safety precautions and protective measures to prevent damage or injury to same. All personal injury or damage to persons or property of any nature, whether in the WORK or appurtenant to it, shall be the responsibility of the Contractor.

e. The Contractor agrees by submission of a bid to indemnify and hold the Owner, its officers, agents, employees, and the Engineer harmless from any and all liability claims, costs and expenses including expenses of investigation and defending against same in regard thereto.

f. Blasting shall only be permitted in hours approved by the Engineer and regulatory agencies having jurisdiction. Blasting will not be permitted on legal holidays.

**Pre-Blasting**

a. Inspections of all structures within [300-feet] of the blast site shall be made more than 2 weeks prior to commencement of blasting. A qualified independent inspector shall perform the inspections for the purpose of detecting and documenting any visible or reasonable recognizable pre-existing defects or damages in structures.

b. Waiver of inspections shall be in writing, signed by structure owners or persons with control or custody of the structures.

c. Complete inspection reports listing findings with photographs or waivers shall be signed by the inspector. One copy of inspection reports and waivers, shall be submitted to the Engineer before blasting commences.

d. The Contractor shall give 30 and 5-day notices to all residence and businesses, and utility owners which may be affected by blasting.

**Blasting**

a. The Contractor shall perform instrumented seismographic monitoring on blasting. A seismograph shall be placed at [the nearest structure to the blast] to monitor the ground motion particle velocity and frequency during each blast. One copy of each daily seismograph chart shall be furnished to Engineer.

b. Fly rock from blasting shall be contained within the project site and shall not represent a hazard to persons, vehicles, existing improvements, or vegetation.

c. The blasting site shall be cleaned of all debris at the end of each day.

d. No blasting shall be done within 100-feet of concrete which has been placed in less than 7 days, except by permission of the Engineer.

**Post-Blasting**

The Contractor shall submit an As-built layout plan showing the extent of the rock excavation/blasting area (Before and after excavation within the claiming period) with indication of hard rock area rock's spot levels.

The independent inspector shall investigate each complaint of property damage and a written report shall be furnished to the Engineer within 30 days of receipt of the complaint.

## 2.15 MEASUREMENT & PAYMENT

Excavation shall be measured per cubic Meter/ft on the assumption of vertically excavated walls required for the nominal concrete dimensions of the structural members of the foundation shown on the Drawings and paid for at the unit rates entered in the Bill of Quantities, inclusive of backfilling, compaction, disposal of surplus earth, dewatering, bracing, shoring etc.

All horizontal measurements shall be taken from established reference point. At the option of the Engineer-in-charge, the contractor shall leave depth indicators during excavations of such shape and size and in such positions as directed so as to indicate the original ground level as accurately as possible. The contractor shall see that these remain intact till the final measurements are taken.

Disposal of surplus material beyond initial 100 ft lead up to a maximum of 18 miles, shall be paid separately, at the rate approved by the Engineer.

Dewatering shall not be paid separately. All dewatering and pumping out whether due to ground water seepage or otherwise shall be included in the rates as quoted by the Contractor.

**** END OF SECTION****

## SECTION - 3
## TERMITE CONTROL

### 3.01 SCOPE OF WORK

The Work covered by this section of Specifications consists of furnishing all labour, materials, equipment, services, miscellaneous and necessary items required to complete Termite Control Work, related works as indicated on Drawings, specified herein, in the Bill of Quantities and subject to the terms and conditions of the Contract.

The work for anti-termite treatment will includes injection of insecticide in sides and bottom of excavated foundation, trenches, spraying on stockpiled backfill material, filled up earth, injections of the insecticide in floor sub-grade of the building and any other operation, which the specialized firm may considered necessary in context to their guarantee obligations. The scope also covers treatment of all wood works with insecticides before installation in position.

### 3.02 MATERIALS

3.02.1 The chemicals approved by Pakistan Council of Scientific and Industrial Research (PCSIR) like Fiprokil, Biflex, Agenda, Dursbanetc, or approved equivalent, emulsifiable concentrate insecticide, specially formulated to prevent infestation by termites.

3.02.2 The chemical will be diluted with water as per manufacturer/ supplier instructions. Fuel oil will not be permitted as diluents.

3.02.3 Pure turpentine shall be used for dilution of insecticide, in approved proportion for application to woodwork.

### 3.03 METHOD OF APPLICATION

Pesticide solution shall be applied with approved pressure spraying equipment maintaining a pressure of 1N/mm$^2$ (10 Kg/cm$^2$) to all applications on or in earth. Spraying to wood shall be done by hand compression sprayers with an approximate pressure of 0.15 N/mm$^2$ (1.5 Kg/cm$^2$). Mixing and dilution of the concentrate insecticide with water shall be doneat site and as per manufacturer recommendations. This solution shall be sprayed over 500 square feet of surface area.

Rate of application of the solution shall be as per the recommendations of the manufacturer. Insecticide shall penetrate to a depth of 1 inch. (25mm) minimum in porous earth at bottom and at least 50mm at the sides of excavations

### 3.04 EXTENT OF APPLICATION

3.04.1 Soil treatment shall begin after all work of preparation of earth prior to installation of concrete has been done. After application, no additional earth moving or work upon sub grade should be done. No covering of earth or concrete should be applied over soil treatment until at least 24 hours after treatment has been made.

3.04.2 Insecticide solution should not be applied during wet weather, or when the earth surface is excessively wet. Application should be made to all areas beneath concrete slabs-on-grade, including sidewalks and paving abutting buildings for distance of at least 6 feet beyond building line.

3.04.3 Contractor to ensure a continuity of treatment under and around the footings and up to the slab on grade in the form of an envelope.

3.04.4 Care shall be exercised to insure that no marks or damage occurs to the finished structure as a result of the work under this section.

3.04.5 All woodwork for the entire project is to be insecticide treated (before application of solignum). Insecticide shall be sprayed on all surfaces of all the wooden work viz., door frames, blocking, furring, planks, boards etc. before installation. Spraying is to be done at the site, after delivery and before installation. No spraying shall be necessary after field sawing, jointing or installation of such material.

3.04.6 Sides of foundation excavations, grade beam, and similar areas shall be treated with solution at a rate of 0.5 lit per square feet upon inner sides of such excavations, and at all locations where concrete slabs for platforms and similar work about the building. Similar treatment shall be made at all locations where expansion Joints, control joints, column bases and similar work occur at or below grade slabs.

3.04.7 In the areas of application signs shall be fixed to show that soil treatment has been applied. Such signs shall be removed when areas are covered by other construction.

3.04.8 All excavations, all walls and bottoms of all pits or trenches for footings or foundationsare to be sprayed. Pesticide shall penetrate to a depth of 12‖ minimum in porous earth at bottom and 3‖ minimum at sides of excavations.

3.04.9 Stockpiled excavated material to be used as backfill is to be spray treated as above. After backfilling to plinth level, area of the whole building up to 10 ft. outside the building line is again to be sprayed penetrating a minimum of 12‖ into soil.

3.04.10 After grading, compaction and leveling and before formation of hard core/soling underfloor slabs, all areas to receive slabs shall be sprayed with pesticides, penetrating a minimum of 12‖ into soil.

## 3.05 LOCATION AND SCHEDULING

3.05.1 Saturation of earth is to be done by adequate personnel and in such a manner as toin no way disrupt the progress of Work.

3.05.2 Care shall be exercised to ensure that no marks or damage occurs to the finished building as a result of the work under this section and the Contractor shall verify and ensure that no material used herein will impede the growth of grass or plants at areas where spraying is done.

## 3.06 APPLICABLE STANDARDS

All methods of termite protection used herein shall be in accordance with best standard practices of National Pest Control Association, USA and the British Wood Preserving Association.

## 3.07 QUALITY ASSURANCE

In addition to the requirements of these specifications, the contractor shall comply with manufacturer's instructions and recommendations for the work, including preparation of substrata and application.

A professional operator shall be engaged who shall have license in accordance with regulations of governing authorities for application of soil treatment solution.

## 3.08 GUARANTEE

The Contractor is to guarantee that the building shall be free from termite (white ants), wood bores and other pests or rodents which cause damage to wood or other organic material for at least 10 years from the date of acceptance of the building.

In the event of any damage caused within the guarantee period, the Contractor shall replace at his own cost such damaged material, finishes and affected portion thereof and suitably preserve and treat the entire premises with the best method known to the trade to prevent the spreading of termites.

## 3.09 TESTING

The Contractor shall supply samples of all the materials to be used for insecticide control for approval of the Engineer-in-charge.

All materials and samples shall be subject to standard testing in accordance with the standards specified herein and shall be rejected if found below these standards. Rejected materials shall be removed from the Site immediately.

## 3.10 MEASUREMENT AND PAYMENT

Only the top surface area of the finished floor or pavement shall be measured for the payment of termite proofing work of the whole project carried out under this section. The measurement will be made in square feet/ meter and paid for at the unit rates entered in the Bill of Quantities.

**** END OF SECTION****

## SECTION - 4
## PLAIN AND REINFORCED CONCRETE

### 4.01 SCOPE OF WORK

The Work covered by this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with plain and/or reinforced concrete work complete in strict accordance with this section of Specifications, applicable Drawings and subject to the terms and conditions of this Contract.

### 4.02 APPLICABLE STANDARDS

Latest editions of the following Pakistan, British and ASTM ACI Standards are relevant to these specifications wherever applicable.

#### 4.02.1 Pakistan Standards

| | |
|---|---|
| PS233 | Portland Cement (ordinary & rapid hardening) |
| PS243 | Natural aggregates for concrete |
| PS279 | Abrasion of coarse aggregates by the use of Los Angeles machine. |
| PS280 | Determination of aggregates crushing value |
| PS281 | Organic impurities in sand for concrete aggregate. |
| PS282 | Material finer than No. 200 BS test sieve in aggregates, method of test for |
| PS283 | Soundness test for aggregates by the use of sodium sulphate or |
| PS284 | magnesium sulphate. |
| PS285 | Sampling aggregates for concrete |
| PS286 | Sieve or screen analysis of fine and coarse |
| PS421 | Description and classification of mineral aggregates |
| PS422 | Sampling fresh concrete |
| PS560 | Slump test for concrete |
| | Making and curing concrete compression test specimen in the field. |
| PS612 | Sulphate-resistant Portland cement type 'A' and sampling fresh concrete in the laboratory. |
| PS716 | Mixing |
| PS717 | Compacting factor test for concrete |
| PS746 | Definitions and terminology of cements |
| PS849 | Making and curing concrete compression test cubes. |

#### 4.02.2 ASTM (American Society for Testing and Materials)

| | |
|---|---|
| C33 | Standard Test Method for Fine and coarse aggregates |
| | Organic impurities in sand for concrete. |
| C39 | Standard Test Method for Compressive Strength of Cylindrical Concrete |
| C40 | Specimens |
| C87 | Effect of organic impurities in fine aggregates on strength of mortar. |
| | Soundness of aggregates. |
| C88 | Ready mixed Concrete. |
| C91 | Cement Standards and Concrete Standards |
| C94 | Compressive strength of hydraulic cement mortars |
| C 109 | Material finer than No. 200 (0.075mm) sieve |
| C 117 | Light weight pieces in aggregates. |
| C 123 | Concrete and concrete aggregates. |
| C 125 | Specific gravity and absorption of coarse aggregate. |
| C 127 | Specific gravity and absorption of fine aggregate. |
| C 128 | Resistance to abrasion of small size coarse aggregate. |

| | |
|---|---|
| C 131 | Sieve or screen analysis of fine and coarse aggregate. |
| C 136 | Clay lumps and friable particles in aggregates. |
| C 142 | Slump of Portland Cement Concrete |
| C 143 | |
| C150 | Standard Specification for Portland Cement |
| C156 | Water retention by concrete curing material |
| C171 | Sheet material for curing concrete. |
| C185 | Air content or hydraulic cement mortar. |
| C188 | Density of hydraulic cement. |
| C191 | Time of setting of hydraulic cement by vicat needle |
| C260 | Air entraining admixture for concrete. |
| C289 | Potential reactivity of aggregate. |
| C309 | Liquid membrane forming compounds for curing concrete. |
| C387 | Chemical admixtures for concrete. |
| C494 | Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete |
| C535 | |
| C75 | Resistance to abrasion of large size coarse aggregates. |
| C994 | Aggregate sampling. |
| C1190 | Preformed expansion joint filler for concrete. |
| C1715 | Concrete joint sealer (hot poured elastic type). |
| D1850 | Preformed expansion joint filler for concrete paving and structural concrete. |
| E11 | Concrete joint sealer (cold application type). |
| E96 | Wire cloth sleeves for testing purposes. |
| E154 | Water vapor transmission of materials in sheet form. |
| E337 | Materials for use as vapor barrier under concrete slabs. |
| | Relative humidity by wet and dry bulk psychrometer. |

4.02.3 **ACI (American Concrete Institute)**

| | |
|---|---|
| 211 | Recommended practice for selecting proportions for normal and heavy weight concrete. |
| 214 | Quality control charts |
| 301 | Specifications for structural concrete for building. |
| 304 | Recommended practice for measuring, mixing, transporting and placing concrete. |
| 305 | Hot weather concreting. |
| 308 | Recommended practice for curing concrete. |
| 309 | Recommended practice for consolidation of concrete |
| 315 | Manual of standard practice of detailing reinforcement concrete structure. |
| 318 | |
| 347 | Building code requirement of reinforced concrete. |
| | Recommended practice for concrete formwork. |

4.02.4 **British Standards**

| | |
|---|---|
| BS 12 | Specifications for Portland cement, ordinary and rapid hardening |
| BS 410 | Specifications for Test Sieve |
| BS 812 | Specification for aggregates from natural sources for concrete Method of testing concrete |
| BS 822 | Test for water making concrete |
| BS 1881 | Method for determination of Compressive Strength of Concrete Cubes |
| BS 1348 | Rigid expanded polyvinyl chloride for thermal insulation. |
| BS 3837 | Sulphate-resisting Portland cement |
| BS 4027 | Specification for Sulfate-Resisting Portland Cement |
| CP 8110 | |

| | |
|---|---|
| CP 114<br>BS 4550<br>BS 8500 | Specifications for Design and Construction of Reinforced and Pre-stressed Concrete<br>The Structural Use of Reinforced Concrete in Buildings<br>Methods of Testing Cement<br>Concrete – Complementary British Standard |

In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other Standards as may be specified by the Engineer for special Materials and Construction are also relevant.

## 4.03 GENERAL

4.03.1 Until and unless specified or directed otherwise by the Engineer, all materials and workmanship shall be based on the latest versions of applicable ASTM Standards in force at the time of inviting tenders.

4.03.2 Any defective work in the opinion of the Engineer shall be removed and reconstructed without undue delay to the approval of the Engineer and the Contractor shall bear all additional costs incurred.

4.03.3 Any previous checks by the Engineer shall not in any way relieve the Contractor of his responsibility in respect of quality and accuracy of Work.

4.03.4 Full care shall be taken to install embedded items. Embedded items shall be inspected and checks for reinforcements and other materials and items shall be completed and approved before concrete is placed.

4.03.5 The Contractor shall get the bar bending schedules of reinforcement checked and approved from the Engineer prior to the cutting of reinforcement.

4.03.6 The Contractor shall maintain an accurate record of ambient temperature of Site. Ambient temperature shall be measured using mercury thermometers or other thermometers acceptable to the Engineer.

4.03.7 Throughout the concrete work, the Contractor shall employ full time on the Works suitable number of qualified and experienced Engineers whose sole duties shall be asfollows:

- Design of concrete mixes
- Quality control of concrete
- Supervision of mixing, transporting, placing, compacting, finishing, curing and protecting concrete.
- Supervision of sampling and testing.
- Preparation and submission of test certificates and reports.
- Completion and keeping of record.
- Such other duties as the Engineer may direct.

4.03.8 All concrete work including reinforcement etc. shall be carried out in accordance with the applicable requirements of ACI/ASTM/BSS Standards and to the instructions of the Engineer.

## 4.04 MATERIALS

### 4.04.1 Cement

a) Ordinary Portland cement shall be grey normal setting cement of approved make and source and of the specified gravity, fineness and chemical composition fully conforming to British Standard Specifications BS-12 and shall be capable of satisfying all tests such as the tensile strength tests contained therein.

b) Sulphate resistant cement where required shall be sulphate resistant Portland cement of the approved make fully conforming to BS-4027 and satisfying the requirements for fineness, chemical composition, strength, setting time and soundness, etc.

c) For all types of cement described in sub-clauses 4.03.1 (a) & (b) above, the cement shall have a tricalcium aluminate ($C_3A$) content by weight not less than 5% and not more than 8%.

d) For all types of cement described in sub-clauses 4.03.1 (a) & (b) above. The initial setting time shall not be less than 45 minutes and final setting time not more than 10 hours.

e) The supply of cement must be so programmed by the Contractor that at no time the quantity of cement stock shall be less than that required for an average consumption of four weeks. Lorry or truck or other means of transportation for the conveyance of cement to the Site of Work shall be clean, dry, metal-lined and covered from top with water proof sheets, so that cement is sufficiently protected from any deterioration during transit.

f) Cement shall be delivered in sealed bags and be stored in moisture-protected and well-ventilated sheds and each cement supply shall be stored separately.

g) The Contractor shall provide at his own cost on the Site all necessary sheds which shall be perfectly dry, waterproof and adequately protected against ingress of water for the storing of cement to be delivered to the Work, to ensure adequate supplies being available for the Work.

h) Cement, which is damp or contains lumps which cannot be broken to original fineness by finger pressure will be condemned irrespective of age and must be removed from the Site.

i) If any time the Engineer considers that any batch of cement may have deteriorated on Site during storage for any reason, he will direct that tests shallbe made and the batch of cement on the Site which may be in question shall not be used until it has been shown by test to be of satisfactory quality at a laboratory approved or appointed by the Engineer. The Contractor shall bear all costs of such testing. The Contractor without delay shall remove any rejected cement from the Site. Cement reclaimed from cleaning bags or leaking containers shall not be used in the Works and immediately be removedfrom the Site.

j) Cement shall be consumed in the sequence of its arrival at Site unless otherwise directed by the Engineer.

4.04.2 **Aggregates**

a) All fine and coarse aggregates to be used shall be supplied from approved sources, which shall not be changed without permission in writing from the Engineer. Aggregates shall conform to the requirements of applicable ASTM C33-82.

b) Fine aggregates, shall be from an approved source of supply of a uniform quality conforming to ASTM C-33-82 and shall be clean and sharp and free from clay, earth, vegetable and organic matters, alkaline or acid reactions or other deleterious salts or such harmful matters and impurities.

c) Fine aggregates shall conform to the requirements of the relevant ASTM C- 33-82 Specifications, and shall be graded as follows;

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| Sieve Number/Size | Percentage (by weight) passing |
|---|---|
| 9.5 mm (3/8") | 100 |
| 4.75 mm (No. 4) | 95 - 100 |
| 2.36 mm (No. 8) | 80 – 100 |
| 1.18 mm (No. 16) | 50 – 85 |
| 0.6 mm (No. 30) | 25 – 60 |
| 0.3 mm (No. 50) | 10 – 30 |
| 0.15 mm (No. 100) | 2 – 10 |

d) Coarse aggregates shall be approved river gravel or hard crushed stone from a source approved by the Engineer and shall be clean, inert, hard, non-porous and free from laminated particles, sand, dust, salt, lime, chalk, clay, organic impurities or other deleterious matter.

e) Coarse aggregate shall also conform to the requirements of Table 2 of ASTM C-33 and shall be graded as follows:-

For Reinforced Concrete (Nominal Size of Graded Aggregates 20.0 mm to 2.36 mm)

| Sieve Number/Size | Percentage (by weight) passing |
|---|---|
| 25.0 mm | 100 |
| 20.0 mm | 90 – 100 |
| 9.5 mm | 20 – 55 |
| 4.75 mm (No. 4) | 0 – 10 |
| 2.36 mm (No .8) | 0 – 5 |

f) All aggregates shall be stored on properly constructed paving and in bins andthere shall be a physical partition between the stockpiles of coarse and fine aggregates. No mixed up aggregates shall be used in any concrete. Under no circumstances aggregates shall be allowed to be in contact with ground.

g) If required, aggregates shall be washed and screened to the sequence of receipt of supplies unless otherwise directed by the Engineer.

h) All aggregates shall be subjected to the approval of the Engineer. Any aggregates not found to be of the required standard shall be rejected by the Engineer and shall have to be removed from Site without delay. Concrete structures executed with rejected aggregates shall be dismantled and rebuilt at the Contractor's expense.

i) Special fine gravel of 9 mm. size shall be used if called for in the Drawings or as directed by the Engineer.

j) Physical properties of aggregates shall be in accordance with Table 3 of ASTMC33.

### 4.04.3 Water

Water to be used in the Work shall be potable water and shall be free from all impurities whether suspended or dissolved. Further, the water shall not contain any chemical impurities, salts etc. of any kind. Water shall be tested for its fitness in Works in accordance with AASHTO Method T26-51.

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4.04.4 **Admixtures**

a) Suitable admixtures from BCR, Sika, Fosroc, Betocrete C-16or Master Builders or other approved manufacturers may be used in concrete mixes with the prior approval of the Engineer. The amount of admixtures added to each batch of concrete requires careful control and shall be added in the doses as recommended by the manufacturers and approved by the Engineer. The cost of the admixtures shall be deemed to be included in the rates.

b) For use of an admixture, the information required by the Engineer shall be submitted to him for each admixture for his approval.

c) BASF 700 or approved equivalent concrete retarding agent, may be used if required with the approval of Engineer.

## 4.05 CLASSIFICATION OF CONCRETE

Classification of concrete to be used in various parts of the Works shall be as indicated on the Drawings and mentioned in the Bill of Quantities. Unless noted otherwise, all blinding concreteshall be of Class E. The concrete of various grades shall be proportioned as set out in Table-1appended hereto.

Table-1 showing minimum required compressive strengths on 6‖ x 12‖ long test cylinders and minimum quantity of cement required per $m^3$ of finished concrete for various mixes and under various conditions is given below:

**TABLE – 1**

| Class of Concrete | Minimum Qty. of Cement Kg/$m^3$ | Work Cylinder Strength | | Max. Water-Cement Ratio |
|---|---|---|---|---|
| | | @ 7 days (psi) | @ 28 days (psi) | |
| D2 | 540 | 4200 | 6000 | 0.33 |
| D1 | 400 | 3500 | 5000 | 0.40 |
| D | 385 | 3150 | 4500 | 0.42 |
| A3 | 350 | 2800 | 4000 | 0.45 |
| A2 | 325 | 2450 | 3500 | 0.47 |
| A1 | 300 | 2100 | 3000 | 0.50 |
| C | 300 | 1750 | 2500 | 0.50 |
| E | 275 | 1400 | 2000 | 0.52 |
| F | 217 | 875 | 1250 | 0.55 |
| G | 159 | 600 | 850 | - |

**Non-structural Concrete**

Non-structural concrete (NS concrete) shall be used only for non-structural purposes where shown on the Drawing. NS concrete shall be compound of ordinary Portland cement and aggregates complying with this Specification.

The weight of cement mixed with 0.3 cubic meters of combined aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand towels or rammers or by mechanical vibration.

## 4.06 PROPORTIONING OF CONCRETE MIXES

All concrete shall be proportioned by weight for design of concrete mixes, unless specifically agreed by the Engineer to proportion them by volume, which permission shall be given only if the arrangements made at Site are satisfactory. The Contractor shall submit to the Engineer proposed mix designs for concrete to be used, based on preliminary laboratory tests to determine proportion of cement, aggregates and water in the concrete conforming to the qualityand strength requirements specified herein. Preliminary test results of at least three different mixes of each class of concrete with varied water-cement ratio shall be submitted. The results of 7 days and 28 days cylinder tests shall be used to establish the ratio between 7 days and 28 days strengths of used concrete. The Engineer may make adjustments in the ratio of fine to coarse aggregates in the mix for a certain work. Preliminary design of mixes and testing shall be the responsibility of the Contractor at his own cost. The proportion of voids in between the coarse aggregate shall be controlled and if it exceeds 0.45%, the Contractor without any charge shall increase sand and consequently the cement. If the proportion is less than 0.45%, sand shall be decreased but not the cement.

The detailed data, calculations and test results shall be compiled in a report and the proposed mix be declared by the Contractor. The report shall be submitted to the Engineer in time before commencing the concrete works and all test results shall be to the Engineer‘s satisfaction.

Lack of approval by Engineer shall not constitute a reason for an extension of time or additionalcosts.

### 4.06.1 No Fines Concrete

"No Fines" concrete shall consist of approved aggregate graded between 40mm and 20mm with not more than 5% passing the 20mm sieve.

The mix shall consist of 0.25 cu m of aggregate to 50kg cement. The aggregate is to bedamp at the time of mixing and the water/cement ratio is to be strictly controlled to evenly wet the aggregate with grout.

The concrete is to be placed as quickly as possible after mixing and is to be lightly rodded to assist placing. The concrete shall not be vibrated or rammed.

### 4.06.2 Maximum Allowable Water Content

All concrete specimens shall be made, cured and tested in accordance with ASTM Standard. A curve representing the relation between the water content and the average 28 days compressive strength or earlier strength at which the concrete is to receive its full working load shall be established for a range of values including all the compressivestrengths shown on the plans. The curve shall be established by at least four points, each point representing average values for at least four test specimens. The maximumallowable water content for the concrete shall be as determined from this curve and shall correspond to a strength 15% greater than indicated on the plans. However, the water cement ratio shall not exceed the value given in Table-1 above for the class/strength of concrete specified. No substitution shall be made in the materials used in the work without additional tests in accordance herewith to indicate that the quality of the concrete is satisfactory.

### 4.06.3 Slump Test

The slump for concrete, determined in accordance with ASTM C-143 Test for Concrete,shall be minimum of 2‖ and maximum of 4‖ provided the requisite strength is obtained.Corrective additions to remedy deficiencies in aggregate gradations shall be used only with the written approval of the Engineer. When such additions are permitted, the material shall be measured separately for each batch of concrete.

## 4.07 BATCHING AND MIXING

Concrete shall be mixed by a mechanical batch type mixing plant with adequate facilities for accurate measurements and control of each material entering the mixer and for changing the proportions to conform to varying conditions of the Work. The mixing plant assembly shall permit ready inspection of operations at all times. The plant and its location shall be subject to approval of the Engineer.

Water shall be measured for every batch with due allowance for water already present in aggregates.

### 4.07.1 Batching Units

Batching units shall be supplied with the following items:-

a) Weighing unit shall be provided for each type of material to indicate the scale load at convenient stages of the weighing operations. Weighing units shall be checked at times directed by and in the presence of the Engineer and required adjustments shall be made before further use.

b) Water mechanism shall be tight, with the valves interlocked so that the discharge valve cannot be opened before the filling valve is fully closed and shall be fitted with a graduated gauge.

c) Discharge gate shall control the mix to produce a ribboning and mixing of cement with aggregates. Delivery of materials from the batching equipment to the mixer shall be accurate within the following limits:-

| Materials | Percentage by Weight |
|---|---|
| Cement | +1% |
| Water | +1% |
| Aggregate smaller than 3/4" | +2% |
| Aggregate larger than 3/4" | +3% |

### 4.07.2 Mixing Units

a) Mixers shall not be charged in excess of rated capacity nor be operated in excess of rated speed. Excessive mixing requiring addition of water to preserve required consistency shall not be permitted. The entire batch shall be discharged and discarded before re-charging.

b) Mixing time shall be measured from the instant water is introduced into the mixer drum containing all solids. All mixing water shall be introduced before one-fourth of the mixing time has elapsed. Mixing time for mixers of one cubicmeter or less shall be not less than 2 minutes; for larger than one cubic meter capacity mixers, time shall be increased by 15 seconds for each additional half cubic meter or fraction thereof, which may be varied if the charging and mixingoperations fail to result in the required uniformity in composition and consistence within a batch and from batch to batch. If an air-entraining agent is allowed to be used, additional mixing time shall be allowed so as to providethe specified air-content.

c) Unless waived by the Engineer, device such as discharge-lock to lock the discharge mechanism, until the required mixing time has elapsed, shall be provided on each mixer. Mixing shall continue for at least 40 revolutions of mixer drum.

d) No hand mixing under any circumstances even with extra cement shall be permitted. If during concreting, the mixing plant fails, the concrete already poured shall be removed, unless directed otherwise by the Engineer. Mixers, which have been out of use for more than 30 minutes shall be thoroughly cleaned before any further concrete is mixed.

e) The mixing water shall be regularly sampled and tested for salt content and contamination.

## 4.08 SAMPLES AND TESTING

### 4.08.1 General

Test cylinders of concrete shall be prepared and stored by the Contractor in accordance with the ASTM C-172, as and when directed by the Engineer. Test cylinders and the concrete materials shall be tested in an approved laboratory and the Contractor shall bear all charges for the same, including such other tests as may be determined by and acceptable to the Engineer.

### 4.08.2 Water

Water shall be tested in accordance with AASHTO Method of Test T26-51.

### 4.08.3 Cement

Cement shall be tested as prescribed in BS-12.

### 4.08.4 Aggregate

Aggregates shall be tested as prescribed in ASTM C-33. In addition, fine aggregatesshall be tested for organic impurities in conformity with ASTM C-40.

### 4.08.5 Reinforcement

Reinforcement bars shall be tested as prescribed in BS 4449, BS-4461 and ASTM A- 615-82(S1) for deformed steel bars and mild steel plain bars. Refer clause 4.10 of thissection for specification requirements of reinforcement works.

### 4.08.6 Testing of Concrete

#### 4.08.6.1 Concrete Compressive Strength Test

a) Works Test Cylinders shall be made of all structural concrete incorporated into the works. Unless otherwise directed by the Engineer, one set of cylinder of any particular mix shall be taken from either :-
   - Each 350 Cft or part thereof in columns
   - Each 1050 Cft in walls and small foundations
   - Each 1750 Cft in slabs, beams and large foundations, or
   - each day's production

   Whichever is the more frequent

b) Each set of the Works Test Cylinders shall comprise six 6‖x12‖ Cylinders made from a single sample of concrete taken from the point of final deposition of the set concrete under the Engineer's supervision.

c) The sampling, making, curing and testing of Works Test Cylinders shall be carried out in accordance with ASTM C3 & C39. Test results shall be recorded on approved forms and submitted in duplicate to the Engineer immediately following the test.

d) A sample of concrete shall be taken at random on eight separate occasions during each of the first five days of using that mix. The number of samples per day and the times which they are taken shall be varied at random (thereafter at least one sample shall be taken each day the concrete of that particular mix is made).

e) From each sample six Cylinders shall be made, two for test at seven days, and the other four for test at twenty-eight days.

f) Specimens shall be cured under laboratory conditions except that the Engineer may require curing under field conditions in which case strength of field cured specimens shall not be less than 85% of that of companion laboratory condition cured specimens.

g) All cylinder moulds shall be steel moulds perfectly true, having all internal and meeting faces machined to a smooth surface.

h) If the strength tests of the laboratory cured specimens for any portion of the Work falls below the minimum allowable compressive strength at 28 days required for the class of concrete used in that portion, the Engineer shall have the right to order replacement of the affected work.

i) All test specimens shall bear distinguishing mark showing number, date of casting, quality of concrete and place from where sample was taken. A proper daily record of test specimens made and test results obtained shall be maintained by the Contractor and weekly test results shall be submitted to the Engineer.

4.08.6.2 Testing for Chloride Ion Content

Maximum water soluble chloride ion concentrations in hardened concrete atages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitious materials, and admixtures shall not exceed 0.15% by weight of cement. To determine water soluble chloride ion content, test procedures shall conform to ASTM C 1218.

4.08.7 **Concrete Members not complying with Specifications**

(i) Where concrete in the Works does not comply with the Specifications, the Engineer may order any or all of the following or any other appropriate action to be taken:

(a) The drilling of test cylinders in mass concrete and testing the cylindersto destruction by compression.

(b) The carrying out of load tests or other non-destructive tests on concrete structure.

(c) The cutting out and replacement of such volume as is considered defective by the Engineer.

(d) Strengthening of the structure in accordance with the requirements and as proposed by the Engineer.

(ii) The Contractor shall carry out all such tests, investigations, rehabilitation or replacement in coordination with and as acceptable to the Engineer at no additional cost to the Employer.

## 4.09 TRANSPORTING AND PLACING CONCRETE

4.09.1 **General**

a) Concreting shall be conveyed and deposited as quickly as possible after mixing and shall proceed so that, as far as possible, a complete section of the Work is done in oneoperation. The concrete may be distributed in barrows, skips, and chutes and by any other method such as pumps, conveyor belts etc. all to the approval of the Engineer.

b) Transportation of concrete shall be in a manner approved by the Engineer and shall beso as to avoid segregation or loss of ingredients of concrete.

c) All foundations and portions of Work to be concreted shall be approved by the Engineer in writing before concrete is poured.

d) All forms and reinforcement shall be completed, cleaned, inspected and approved before pouring of concrete. No concrete is to be deposited till the Engineer has inspected and approved in writing all reinforcement, foundations, forms, details, positioning of all fixtures and materials to be embedded in concrete, control levels and screeds, etc. and is satisfied with the arrangements the Contractor has made to efficiently proceed with the work such as sufficient labour, materials, plants etc. Such an approval will not relieve the Contractor from any of his obligations under this Contract. No concrete shall be deposited without the written permission from the Engineer who shall have no authority to waive off this condition. Any concrete without such written authorization shall be liable to be rejected.

e) Placing of concrete shall not be permitted when, in the opinion of the Engineer the sun,heat, wind, cold, snow, or limitations or facilities furnished by the Contractor prevent proper placing, finishing and curing of concrete.

f) All concrete shall be thoroughly compacted and consolidated by means of pneumatic or mechanical immersion type vibrators of suitable size having minimum frequency of 8000 RPM. Care shall be taken to avoid segregation due to excessive vibration. The Contractor shall maintain on Site at all times one or more standby vibrators. Tapping or other external vibration of forms shall not be allowed unless so directed by the Engineer. In that case formwork shall be adequate to withstand vibrations. Compaction shall be done until the whole mass assumes a jelly like appearance and consistency with water just appearing on the surface. Concrete shall be sufficiently tamped and consolidated around the steel bars, care shall be taken that the vibrator does not touchsteel or formwork, and is worked into all parts of the moulds in order that no voids or cavities are left. Steel shall not be disturbed during operations of concreting. Concrete shall be brought up in even layers not more than 8‖ thickness and worked against side of forms to give a smooth and uniform surface. No surplus water shall be allowed to come out and lie on the surface of concrete. The concrete must be of such a consistency that when ramming, consolidating and tamping is completed, a thin film ofwater is just appearing on the surface. In vibrating, care shall be taken to avoid displacing the reinforcement.

g) Hardened concrete, debris and foreign materials shall be removed from interior of forms and from inner surface of mixing and conveying equipment.

h) Runways and gangways shall be provided for wheeled concrete handling equipment and workmen, and such equipment shall not be wheeled over reinforcement, nor shall runways be supported on reinforcement.

i) Concrete shall not be dropped freely from a height of more than 10 ½ ft. in columns and 4 ft. elsewhere. In cases where an excessive drop is inevitable, the Contractor shall provide spouts, down pipes, chutes, or side ports to forms with pockets, which willlet concrete stop and flow easily into the form without any risk of segregation. The discharge of the spouts, down pipes or chutes shall be controlled so that the concrete may be effectively compacted into horizontal layers not more than 8‖ thick.

j) Concrete is to be deposited as quickly as possible after mixing and to proceed continuously. Concrete which has attained its initial set or has contained its mixing water for more than 30 minutes shall not be allowed to be placed in the work.

k) When concrete is laid on hard core, such as sub-grade for floor slabs, or other absorbent material, the surface is to be watered, consolidated and, where specified, blinded before the concrete is deposited.

l) Fresh concrete shall not be placed on previously laid concrete or on old concrete surfaces until the latter has been cleaned of all dirt, scum and laitence by wire brushes. The clean surface shall then be thoroughly wetted and grouted with cement slurry as approved by the Engineer.

m) Care shall be taken not to disturb newly placed concrete by vibrator, indirect loading or otherwise. No traffic or loading shall be allowed on the concrete until it has thoroughly set and hardened.

n) Construction joints in concrete shall only be given at locations indicated on thedrawings or as approved by the Engineer. If approved by the Engineer, the concrete at the end of the day's work shall be finished off against a temporary shutter stop, which shall be vertical and securely fixed. Such stops shall be removed within 24 hours of placing of concrete. Construction joints not shown on the Drawings shall be reinforcedwith steel bars or dowels, if deemed necessary by the Engineer, and shall be furnishedby the Contractor without any additional cost.

o) No concrete shall be placed during rains or inclement weather and all fresh concrete shall be suitably protected from rain fall and excessive heat or cold.

p) Should any part of the exposed surface present a rough, uneven or imperfect appearance, when the shuttering is removed, it shall be picked out to such depth and refilled and properly re-surfaced and entirely redone as per directions and approval of the Engineer at the cost of the Contractor.

q) On removal of the forms and before the concrete skin has had time to harden, all facesof the concrete inside and outside to be kept exposed (i.e. unplastered) shall be rubbed over with carborundum stone, and washed with cement to remove all marks, projections, hollows, or any other defect. No extra payment shall be made for this work.

r) All exposed surfaces and lines of the concrete work are to be true and fair without cracks, bends, windings and distortions of all kinds, without any extra charges by the Contractor. All concrete work to remain exposed and unplastered is to be fairfaced, smooth, pleasing and to the entire satisfaction of the Engineer.

s) A float or screed is to be worked over the exposed surfaces of all concrete work on theflat or curve, so as to render the surfaces perfectly smooth, clear and to the necessary slopes or falls or as required to receive the floor or roof finishes according to the Drawings and as directed by the Engineer without any extra charge by the Contractor.

4.09.2 **Temperature**

No concrete shall be mixed or placed while the temperature is above 35 degrees centigrade(°C) on a rising thermometer or above 40 degrees centigrade (°C) on a falling thermometer.

The Contractor shall supply an accurate maximum and minimum thermometer and hang it in an approved position in the Works.

The Contractor shall plan the day's concrete in such a manner as to ensure that each bay orpanel is completed at a proper construction joint before the temperature rises above the permissible limit.

The Contractor shall allow in his rates for any additional expenses incurred by complying with this Clause in order to complete the works within the "Time for Completion".

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4.09.3 **Hot Weather Concreting**

Hot Weather Concreting Operation should conform to the provisions of ACI Standard 305-72 ―Recommended Practice for Hot Weather Concreting‖. The following precautions should be adopted as necessary to comply with the above limit:-

a. Shading of aggregate stock piles.
b. Insulation of water tanks and pipelines and formwork.
c. Refrigeration of mixing water.
d. Addition of ice to mix to lower temperature.
e. Shading of formwork and reinforcement from the sun and drying winds.
f. Cooling of formwork and reinforcement prior to and ahead of casting of the concrete by mist spraying.
g. Covering and spraying with water of hardening concrete surfaces.
h. Concreting during the cooler part of the day.

## 4.10 PROTECTION AND CURING

All exposed concrete shall be cured. Curing shall be accomplished by preventing loss of moisture, rapid temperature change and mechanical injury or injury from rain or flowing water for a period of at least seven (7) days. Curing shall be started as soon as the concrete has hardened sufficiently for the surface not to be marked. Curing shall be done either by coveringwith sand, hessian, canvas or other approved fabric mats, which shall be kept continuously wet. If required and so directed by the Engineer, formed surface with forms in position shall also be cured by keeping all forms continuously wet. As an alternative, curing of concrete on all exposed surfaces which could not be kept covered, such as sides of the beams, under side of the slabs, may also be done by sealing concrete surface with liquid membrane-forming curing compounds white pigment type conforming to ASTM C-309 or equal so as to arrest loss of moisture from concrete, with the approval of the Engineer. Care shall be taken so as to spray the compound/chemical on all the exposed faces of concrete so that no loss of moisture takesplace. The Contractor shall take special care that curing of concrete is satisfactorily carried out and in accordance with methods specified herein and/or as instructed by the Engineer.

Any negligence in this regard may result in total rejection of such concrete works, which in the opinion of the Engineer have not been adequately cured. Period of curing for any concrete shallbe 7 days or more as directed by the Engineer. All concrete pours and concrete structures shallbe clearly marked with non-washable paints to indicate the date of placing concrete. During hotweather, curing shall be done even at night. It shall be obligatory on the part of the Contractor to obtain a certificate from the Engineer that the curing has been properly done. A suitable format shall be printed and kept on Site to be signed by the Engineer for every part of the Work.

For sections 5 ft. or more thick, the Contractor shall ensure that the temperature differential between the inner and outer surfaces shall not exceed 20°C and shall submit to the Engineer his proposals to control and monitor this.

## 4.11 CONSTRUCTION JOINTS

Construction joints shall be located as indicated on the Drawings and/or as approved or directed by the Engineer. Prior to construction of any structure, the Contractor shall submit a proposal showing location of construction joints and sequence of construction to suit his concreting programmed for the approval of the Engineer. Joint in columns shall be made at the undersideof the deepest beam framing thereto. Beam stems and slabs shall be poured monolithically unless allowed otherwise by the Engineer in writing. Joints not specified or shown on the Drawings if so required and approved by the Engineer, shall be so located as to least impair the strength and appearance of the Work.

Except and where indicated on the Drawings, no jointing shall be made in footings or foundations without written approval of the Engineer. Construction joints shall be at right angles to the member and shall be formed against firm stopboards. The stop board shall be removed as soon as possible after placing the concrete but without the risk of movement of the concrete and the concrete surface shall be well brushed with a hard brush and washed off with a spray of water, two to four hours after casting, to expose the aggregate and provide key for the next pour.

In all water retaining structures and other substructure pits and trenches, P.V.C. or any other approved water stops shall be provided at the construction joints in the manner shown on the Drawings and/or approved by the Engineer.

Whenever a section of concrete is left unfinished, for any reasons with the approval of the Engineer, leaving surface which will be hard-set before additional concrete can be joined to it, such dovetails, grooves or other bonds shall be provided as may be necessary to ensure a good bond with the new work, at the cost of the Contractor. Before deposition fresh concrete upon or against any concrete which is already set, the surface of the set concrete shall be roughened with a cutting tool, any laitance removed, thoroughly cleaned from all foreign matter, well-watered and covered with approved bonding agent and cement grout, and special care shall be taken to ram the fresh concrete thoroughly up and against the set concrete; and, if deemed necessary by the Engineer, the joints shall be reinforced with steel bars or dowels to be all furnished and done by the Contractor without any additional cost.

## 4.12 CONCRETE FLOOR SLAB FINISHING

Concrete slabs shall be finished as described herein. In preparation for finishing, floor slabs shall be struck off to the required level at or below the elevation or grade of the finished floors as shown on the Drawings. Floors shall be leveled with a tolerance of 1 mm in 1m. Where drains occur, the floor surface shall be pitched to the drains as indicated on the Drawings or asdirected by the Engineer.

## 4.13 MONOLITHIC FINISH

All concrete surfaces in floors, except where other finish is specified, shall be finished by steelfloats or straight edges to bring the surface to the required finish level as shown on the Drawings. While the concrete is still green, but sufficiently hardened to bear a man's weight without deep imprint, it shall be wood floated to a true even plane with no coarse aggregate visible. Sufficient pressure shall be used on the wood floats to bring moisture to the surface. The concrete shall then be hand trowelled to produce smooth impervious surface free from trowel marks. If necessary, the process shall be repeated so that the final finish shall produce ringing sound from the trowel. No separate payment shall be made for finishing floor slabs in the aforementioned manner.

## 4.14 CONCRETE TOPPING

Where indicated on the Drawings, base slab under concrete topping shall receive a screeded finish. After the base slab is thoroughly cured and when directed, concrete topping shall be laid to the thickness as indicated on the Drawings in alternate panels of suitable sizes as directed by the Engineer.

## 4.15 ANCHOR BOLTS, INSERTS, SLEEVES, CHASSIS, RECESSES, STEEL FRAMES

The Contractor shall provide chases and openings required for other sections of the Works and will cooperate and coordinate with other trades in placing their pipes, ducts, recesses and other built-in items as the Work proceeds, entirely at his own cost and risk.

The Contractor shall furnish and place in position accurately, as shown on the Drawings, all inserts, sleeves, chases, recesses, etc., supplied by the Contractor, subcontractors or other contractors, as directed. Full cooperation and coordination shall be maintained with other contractors, subcontractors in this regard.

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## 4.16 WATERPROOF CONCRETE

Waterproof concrete shall consist of structural concrete as specified herein and with the addition of an approved waterproofing additive. This shall be mixed in accordance with the manufacturer's instructions and as detailed in the Bill of Quantities.

Contractor's attention is drawn to the special care required for casting roof framing, ponds, swimming pools and all underground structures including basement floor, retaining walls, sumps, pits, etc. These are all designed to BS 8007, British Standard for water retaining structures. The contractor shall ensure that workmanship and curing is up to the required standard. The crack widths in such structures shall not exceed 0.2mm.

The Contractor shall take full responsibility for ensuring that the resulting construction is completely watertight and free from penetration of moisture.

When in the opinion of the Engineer, damp patches and/or leakage of water in the finished work are due to failure of the Contractor to comply with this specification, the affected work shall be made good at the Contractor's expense.

Water-stoppers shall be provided in all construction joints and the type of Water-stoppers will be as specified or to the approval of the Engineer. All Water-stoppers will be joined by welding strictly in accordance with the manufacturer's recommendations and all multiple joints and special intersections shall be manufactured by the supplier.

Before commencement of work, the Contractor shall obtain the Engineer's approval of the methods to be used to support and maintain the Water-stoppers in the correct location while the concrete is placed and also the layout and form of all additional construction joints other than those shown on the drawings. Unless indicated otherwise on the drawings, all construction joints in waterproof concrete shall be formed incorporating Water-stoppers to Engineer's approval.

All service holes cast in shall incorporate sleeves with puddle flanges and temporary openings for services should incorporate Water-stoppers.

Care shall be taken at all times to ensure that Water-stoppers are not perforated or damaged in any way and the concrete shall be carefully placed and compacted around the Water- stoppers to ensure void free impervious concrete.

All kickers or starter plinths to walls (if used) on the periphery of the watertight construction shall be cast monolithically with the base.

The formwork shall comply with this Specification and in addition any bolt or fastening embedded in or passing through the concrete shall be to the approval of the Engineer and not impair the water tightness of the structure. The use of through bolts and sleeves is strictly prohibited.

Special attention shall be given to the elimination of shrinkage or thermal cracking. The size of any bay or slab or wall and sequence of pouring shall be such as to minimize cracking.

Slotted inserts or sockets cast into the structural concrete shall be provided for all fixings including services. The cutting of holes in watertight concrete is strictly prohibited.

The Contractor is completely responsible for making all basements and swimming pools absolutely watertight. If any leakages or moist patches occur, the cost of any repairs, etc. to make the basement and swimming pool fully watertight will be borne by him. The Contractor is to give a ten year guarantee for water tightness, reckoned from the date of completion of roof framing, basement and swimming pool. The form of guarantee is to be to the satisfaction of the Client. Should any leaks or dampness occur during the Guarantee period of ten years, the Contractor shall, at no cost to the Client, immediately re-waterproof the defective area or areas and make good all damages to surface finishes such as plaster, painting, paneling, tiling, etc. electrical or other installations or other property, caused by leaks or dampness or reimburse the Client for making good such damages.

Water tightness of swimming pools shall be inspected and tested in accordance with BS 8007:1987 and/or ACI-350.

## 4.17 CLEANING AND REMOVAL OF RUBBISH

On completion of Works herein, the Contractor shall remove all concrete debris, rubbish, shuttering materials, scraps etc., from the vicinity of the structures completed. All areas shall be cleaned to the satisfaction and approval of the Engineer. The rubbish shall be disposed of within or outside the Site premises, free of cost as directed by the Engineer.

## 4.18 MEASUREMENT AND PAYMENT

a) Concrete works shall be measured and paid for as per theoretical volumes calculated on the basis of the Drawings, or as otherwise approved by the Engineer and paid atper cubic foot at the rates entered in the Bill of Quantities.

Recesses (e.g. openings in slabs, break-through and the like) with an individual volume of more than 1 sq. ft. or 2 cft shall be deducted.

b) The prices for concrete works shall include all cost for the complete work and are not limited to the cost of formwork, its support, anchoring's, chamfers, construction joints etc., the required scaffolding, falsework, temporary works, post-treatment and, if necessary, repair of concrete, all preliminary and routine tests, as well as the required statical checks and drawings for Temporary Works in connection with the concrete works.

c) The cost for special finishing of exposed concrete surfaces such as fair-faced finish etc. shall be included in the unit price applicable to the respective structural member and will not be compensated for separately.

d) The cost of all concrete admixtures and additives shall not be paid for separately and is deemed to be included in the unit rates of respective items of the BOQ.

### Joints

a) Expansion Joints

Expansion joints will be paid per number, according to the Drawings. The prices shall include all costs for the different materials and performances relative to the laying and sealing of the joints.

b) Dummy Joints

Dummy joints required by the Contractor with the Engineer's consent for the sound execution of the Works will not be paid for separately, but the costs involved are deemed to be covered by the concrete prices applicable to the respective structural member.

c) Construction Joints

Construction joints will be measured and paid for as below:

The Contractor is deemed to have covered the costs for all related supplies, laying, formation and performances of construction joints included in the respective concrete prices. However, the cost of PVC water stoppers and or swell bars shall be measured and paid for separately per running foot of accepted lengths.

It the approved pouring sequence has not been followed by the contractor. Any increase in quantity of materials (pvc water stoppers, swell bars, rear guards, sealants, SBR etc.) associated with the construction joints and or additional reinforcement required shall be paid for by the Contractor at his own cost.

**Tamping of Equipment and Grouting of Recesses**

The costs resulting from materials and performances in connection with the tamping of installeditems or the grouting of recesses are deemed to be included in the prices for the supply and/or installation of the respective items, and will therefore not be separately compensated for.

** END OF SECTION**

## SECTION - 5
## REINFORCEMENT STEEL

### 5.01 SCOPE OF WORK

The work covered by this subsection of the Specifications consists of furnishing all materials, tools, labour and in performing all operations in connection with the providing, straightening, cutting, bending, fixing, binding including binding wire, chairs, pins, spacer blocks complete in strict accordance with this subsection of the Specifications, the applicable Drawings, approved bar bending schedule, and the terms and conditions of the Contract.

### 5.02 GENERAL

a) The Contractor shall procure reinforcing steel only from reputable manufacturers / suppliersduly approved by the Engineer.

b) Verification of the source of supply shall be prepared by the Contractor and submitted to the Engineer along with necessary certificates and test reports.

c) The Contractor shall prepare detailed bar cutting and bending schedules on the basis of the working Drawings and in consideration of BS-4466 and of any requirement resulting from the applied bar bending process.

d) The Contractor shall inform the Engineer of the completion of any reinforcement in time, inorder to facilitate its inspection and check of conformity with the working Drawings well before the concreting. Relevant formalities shall be agreed upon between the Contractor and the Engineer at the appropriate time.

e) Reinforcement bar sizes have generally been shown on the Drawings in the form of designated bar numbers.

### 5.03 MATERIAL

a) Reinforcement shall be deformed reinforcement, except that plain reinforcement bars are permitted for spirals. Reinforcing steel bars (Plain and deformed) shall be from the new billet stock of mild steel and shall conform to the British Standard Specifications mentionedbelow and as indicated on the Drawings and Bill of Quantities.

i. Hot rolled deformed bars conforming to ASTM A-615 / BS 4449
ii. Cold worked deformed bars to conforming to BS 4461 (revised 4449-1988)
iii. Plain round steel bars to conforming to BS 4449

b) For each consignment, the Contractor shall furnish to the Engineer the manufacturer‘s mill test certificates to guarantee that the steel supplied meets all the requirements of the relevant specifications and further meets the requirements of specified characteristic strength and minimum tensile strength requirements given as under:-

**High Yield Deformed Steel Bars:**

i. Specified Characteristic Strength:

| | |
|---|---|
| up to 16 mm (5/8‖) | 460 N/mm2 (66,700 psi) |
| over 16 mm (5/8‖) | 425 N/mm2 (61,625 psi) |

ii. Tensile Strength:
Minimum Tensile Strength shall be 10% greater than the Specified Characteristic Strength.

iii. Minimum Elongation

| | |
|---|---|
| up to 16 mm (5/8‖) | 12% |
| over 16 mm (5/8‖) | 14% |

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**Mild Steel Plain Steel Bars:**

(i) Specified Characteristic Strength 250 N/mm2 (36,000 psi)

(ii) Tensile Strength:
Minimum Tensile Strength shall be at least 15% more than the Specified Characteristic Strength.

(iii) Minimum Elongation 22%

a) **Bendability**
All the bars shall be capable of being bent cold through 180 degree round a pin without cracking on the outside of the bent portion as per ASTM-A615.

b) 18 gauge galvanized wire to BS 4482 shall be used for binding the steel reinforcement.

c) Samples shall be tested for above requirements in an approved laboratory before starting the cutting of bars or when so required by the Engineer; and all cost of such tests shall be borne by the Contractor.

d) All reinforcing steel bars shall be free from loose mill scale, loose rust, oil, grease,dirt or other harmful substances.

**Wire Gauze**

General
Unless otherwise specified the wire gauze shall be of best quality approved uniformly, woven wire webbing of 12 x 12 meshes to 645 mm square (one Sq. Inch) made from 22 gauge galvanized iron wire. All panels shall be in one piece and no joints shall be allowed.

Fixing
Wire gauze shall be fixed as shown on the drawings or as directed. The gauze shall remain tight to the fill width without any sag.

## 5.04 STORAGE

Reinforcement bars shall be stored on platform sufficiently above ground surface and be free from scales, oil, and structural defects prior to placement in Works. Rusted or dirty steel bars shall not be used in the Works unless brushed and cleaned by proper steel wire brushes and after being approved for use by the Engineer.

## 5.05 REINFORCEMENT CUTTING AND PLACING

All reinforcement steel shall be cut and bent cold in strict accordance with bar bending schedules prepared by the Contractor and approved by the Engineer. The Contractor shall prepare bar bending schedule from approved structural working Drawings and as per instructions of the Engineer. The bending schedules shall be drawn on approved forms and submitted to the Engineer for checking and approval. The steel reinforcement shall be cut and bent to sizes as per Drawings and approved bending schedules. In case, any bars cut, bent or even fixed in position are found incorrect in dimensions, size and shape and are not according to the requirements of the Drawings or instructions of the Engineer, notwithstanding any previous approval of the Engineer, the Contractor shall replace such steel bars, cut, bent or fixed in position, by correct sizes bars at his own cost and no extra payment shall be made to the Contractor on such account. Suitable spacers, chairs as approved by the Engineer shall beused for the purpose of supporting and spacing of bars. In case, any bars are bent or displaced they shall be straightened or replaced prior to pouring. All reinforcement bars within the limit of a day's pour shall be in place and firmly tied with 18 gauge wires. Bars with kinks or bends not shown on the Drawings shall not be used. Reinforcement bars shall not be used for supportingthe workmen and concreting work. Separate supporting system shall be used for this purpose.

Concrete cover to all reinforcement bars shall be provided as shown in the Drawings using steel chairs and concrete spacer blocks.

The concrete spacer blocks shall be cast from cement sand mix in a ratio of 1:2 in suitable required sizes. These shall be well cured and dry before use in the Works. The spacers shall meet the specified requirements of water absorption. All spacers shall be properly fixed in their required positions and as directed by the Engineer.

For any structural member which shall receive fair-forced concrete surfaces, special spacers shall be used while do not impair the specified appearance of concrete surfaces.

### 5.05.1 Laps and Splices

No splicing of bars shall be allowed at positions other than shown on the Drawings. All lap lengths shall be of the minimum sizes as indicated on the Drawings and in accordance with ACI 318-95. Splices of adjacent bars shall be staggered, unless approved otherwise by the Engineer. All reinforcing steel fixed in position shall be inspected by the Engineer and no concrete shall be poured until steel placement has been approved in writing by the Engineer. For inspection purposes, the Contractor shallgive to the Engineer reasonable notice before the scheduled pouring time. Clear concrete cover to reinforcement steel shall be as specified or indicated on the Drawings.

### 5.05.2 Mesh Reinforcement

a) Where indicated mesh shall be of the sizes as shown on the Drawings and conform to BS 4482 or 4449 with mesh sizes to BS 4483 or ASTM A-185 (WeldedSteel Wire Fabric for Concrete Reinforcement). Mesh reinforcement when used in slabs shall be supported at proper elevations by standard accessories. In slabson ground (porous fill), precast concrete spacer blocks may be substituted for chairs.

b) Overlaps in fabric reinforcement shall be a minimum of two meshes, except where otherwise shown on the Drawings, correctly aligned and at least 50% of the wire intersections shall be tied with 18 gauge tying wire. Laps shall be staggered in adjacent rows of sheets.

## 5.06 MEASUREMENT AND PAYMENT

Reinforcing bars will be measured as per Drawings in consideration of the volumetric weight of 7.85 t/m3, without additions for rolling tolerances, deformations, waste lengths and binding wires and paid per ton at the unit rate entered in the Bill of Quantities.

The prices shall include all costs involved with the supply, transportation, storage and protection, the cutting, bending and placing, inclusive of concrete spacers, supports, stands, tying into position, etc.

Assembly stands, spacers etc., whether designated in the Drawings or not or otherwise demanded by the Engineer will not be measured and paid for separately.

If installed reinforcement must be dismantled under certain circumstances or where additional reinforcing bars are to be provided on Engineer's instruction, the Contractor is not entitled to any compensation, if such additional supplies and/or performances are required and demanded by the Engineer due to the Contractor's faulty execution of the respective work.

**** END OF SECTION****

## SECTION - 6
## FORMWORK

### 6.01 GENERAL

The formwork shall be inclusive of all labour, material, workmanship and alike. All formwork and supports thereto shall be designed by the Contractor and relevant drawings shall be submitted to the Engineer for approval before the Work is put in hand. Such an approval shall not relieve the Contractor from all or any of the obligations of the Contractor or give rise to anyclaims.

### 6.02 MAKING FORMS

The formwork for columns, beams, slabs, foundations, pits, lintels, fins, panels, purdees, parapets and all other works whether to be precast or cast-in-situ shall be of steel plates, scaffolding pipes and joints or other approved material and shall be rigidly formed and designed by the Contractor to the shapes and forms as per Drawings in accordance with the best of the existing practices, so as to be able to withstand without displacement, deflection or deformation or movements of any kind, the pressure of the moist concrete and all other loads. No plank timber formwork will be accepted at any location. Only system formwork will be accepted.

### 6.03 FAIR FACED FINISH

a) Facing Material
The form facing material shall produce a smooth, hard, uniform texture on the concrete. It shall be M.S. steel sheets, plywood, tempered concrete grade hardboard, metal or plastic, or other approved material capable of producing the desired finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surface, worn edges, patches, dents, or other defects which will impair the texture of the concrete surface, shall not be used. Tie holes and defects shall be patched. All fins shall be completely removed.

b) Shop Drawings
Shop Drawings shall be submitted by the Contractor for Engineer‘s approval, showing grooves, joints etc. if indicated on the Drawings or instructed by the Engineer before takingup the job of formwork in hand.

c) Repair
No repair of surfaces designated `fair faced' shall be allowed. Any concrete failing to achieve the desired finish or with defective surfaces shall be removed and replaced at Contractor's expense. The Engineer may reject any defective concrete surface and order it to be cut out in part or in whole and replaced at the Contractor's expenses.

### 6.04 RIGID WITH ALLOWANCE FOR CAMBER & BULGES

The formwork shall be fabricated and erected in position, perfect in alignment, levels and true to plumb and shape and securely braced so as to enable it to withstand all weights, dead and live, to be endured during placing of concrete and its subsequent hardening till the formwork is struck. It shall be sufficiently rigid as not to loose its shape and shall be made to compensate for bulging, and deflection to give the finished concrete the required lines, plumb, size and shape.

### 6.05 EXPOSED SURFACES LEFT UN-PLASTERED

In addition to the provision made elsewhere, for all the concrete work covered in this Contract which are to remain exposed in the finished work and left un-plastered, the formwork shall be smoothly faced by using M.S. steel sheets or lining the shuttering with smooth G.I. sheets or non-absorbent material like Formica sheets or in any manner as approved by the Engineer so as to make a perfectly smooth surface of the finished concrete. Where any surface defects on the exposed concrete surfaces occur and which do not impair the structural performance, being in excess of the designed surfaces and the architectural appearance of the Work in the opinion of the Engineer such

defects may be removed by guniting and grinding with carborundum stone or in any other approved manner, at the cost of the Contractor, otherwise the whole or part of the Work shall be removed and made good by the Contractor, at his own cost. For precast concrete members, the forms shall be rigid, exact and smooth.

## 6.06 MATERIALS AND LABOURS

The Contractor shall supply all materials runners, and labour, necessary for a good and speedy erection of formwork such as steel plates, shuttering planks, struts, bolts, stays, gangways, boards, fillets etc. and shall do all that is essential in executing the job in a workman-like manner to the satisfaction of the Engineer.

## 6.07 FORMWORK NOT TO INTERFERE OR INJURE WORK

The formwork shall be so designed and arranged as to not unduly interfere with concrete during its placing and easy to be removed without injuring the finished concrete. Wedges, clamps, bolts and rods shall be used, when permitted and where practicable, in making the formwork rigid and in holding it to true position.

## 6.08 OPENINGS IN FORMWORK

Wherever concreting is required to be carried out within forms of depth exceeding 6.5 feet, temporary openings in the side of the form shall be provided to facilitate the pouring and consolidation of the concrete. Small temporary openings shall be provided at bottom of the forms to permit the removal of rubbish etc. but the same shall be suitably closed before pouring.

## 6.09 OPENING AND OTHER DETAILS

Provision shall be kept in the formwork such as openings, recesses, holes, pockets, fillets, etc. for housing services and other architectural details in the finished concrete or on its surface and edges as shown on the Drawings or as directed by the Engineer and to fix all necessary inserts, dowels, pipes, holdfasts etc. in concrete as shown on the Drawings or as directed by the Engineer.

## 6.10 JOINTS IN FORMWORK

All joints in the formwork shall be sufficiently closed to prevent leakage of mortar from concrete for concrete surfaces not to be exposed in the finished work. The joints in the finished work shall be close jointed and perfectly smooth so as not to allow any leakage of the mortar from the concrete and show any appearance of leaking mortar on concrete surfaces.

## 6.11 TREATMENT AND INSPECTION OF FORMS

All rubbish particularly chippings, shavings and saw dust shall be removed from the interior of the forms, before placing concrete. Forms shall be coated with approved shuttering oil before reinforcement is placed. Surplus oil on forms and any oil thus applied on reinforcing steel shall be removed. If the forms are not used within 24 hours, a fresh coat of oil shall be given before placing of concrete.

## 6.12 STRIPPING SHUTTERING

Formwork should not be removed until the concrete has developed sufficiently strength to support all loads placed upon it. The time required before formwork removal depends on the structural function of the member and the rate of strength gain of the concrete. The grade of concrete, type of cement, water/cement ratio, temperature during curing etc. influence the rate of strength gain of concrete.

No struts or timbering which serve the purpose of supporting the shuttering or centering shall be struck and removed without permission from the Engineer in writing and the work of striking and removal after the receipt of such permission shall be conducted under the personal supervision of the competent foremen in the employment of the Contractor and the Contractor even after the permission from the Engineer shall hold himself fully responsible for any consequences whatsoever.

In all cases the Engineer will direct and control the minimum period of time for which the forms, shuttering or centering shall remain in place before being struck; but, for the general guidanceof the Contractor, the following are to be considered as the minimum periods for the main classes of Work.

| **Type of Formwork** | **Normal Weather** | **Cold Weather** |
|---|---|---|
| Footing Sides | 24 hours | 36 hours |
| Vertical sides of Beams, Walls and Columns (unloaded) | 24 hours | 36 hours |
| Slab soffits ( up to 15 ft span) | 10 days | 14 days |
| Slab soffits ( > 15 ft span) | 14 days | 21 days |
| Beam soffits ( up to 15 ft span) | 14 days | 21 days |
| Beam soffits ( > 15 ft span) | 21 days | 28 days |

The Engineer may require, however, that any walings, soldiers, struts or other timbers or supports, the removal of which may cause the transference of load to the finished work, to be kept in place for three weeks after the placing of the concrete.

The formwork parts and connections should be arranged in a way that makes formwork removaleasy and simple, prevents damage to concrete and formwork panels so that it can be reused without extensive repair.

The formwork removal procedure should be supervised by the engineer to ensure that quality of hardened concrete in structural member, i.e. it should be free from or has minimum casting defects such as honeycombing, size and shape defects etc. These defects in concrete influence the strength and stability of structure. Thus immediate repair works can be done or the members can be rejected.

The separation of forms should not be done by forcing crowbars against the concrete. It may damage the hardened concrete. This should be achieved by using wooden wedges.

Beam and joist bottoms should remain in place until final removal of all shoring under them aredone.

Joist forms should be designed and removed so that the shores may be removed temporarily to permit removal of joist forms but must be replaced at once. The shores and joists will be dismantled beginning from the middle of the member's span, continuing symmetrically up the supports.

The approval from the engineer should be obtained for the sequence and pattern of formwork removal, prior to start of removal.

## 6.13 INJURY OR DAMAGE

The Contractor shall be responsible for any injury to the Work and any consequential damages caused by or arising from the removal and striking of forms, centering and supports, due to striking too soon. Any advice, permission or approval given by the Engineer relative to the removal and striking of forms, centering and supports shall not relieve the Contractor from the responsibilities herein defined.

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## 6.14 TREATMENT AFTER REMOVAL OF FORMS

Any minor surface honey-combing or other irregularities are to be properly made good immediately upon the removal of the formwork and the surface made good to the satisfaction of the Engineer at the Contractor's own expense. Any small voids shall be neatly repaired with cement mortar consisting of one part of cement to two parts of sand and the whole surface rubbed over with carborundum stone and cement wash to bring the whole to a smooth and pleasing finish and uniform colour.

## 6.15 TOLERANCES

The structure shall be built to dimensions and levels shown on the Architect's drawings.Deviation from true positions and/or levels will be accepted only if they do not affect the finished dimensions, positions and levels as shown on the Architect's drawings.

Permitted tolerances shall be in accordance with the current issue of BS 5606, Code of Practice for Accuracy in building with up-to-date amendments.

Construction Tolerances of Structural Elements Supporting curtain walls or surfaces affecting curtain wall set out:-

- Maximum deviation vertically from defined position immediately after stripping of formwork ±12mm.
- Maximum deviation laterally from defined position immediately after stripping formwork and prior to any pre-stressing (if used) ±12mm or building height/4000 whichever is greater. This laterally out of position tolerance includes all local deviations in edge of slab or edge beams as well as overall building tolerance.

NOTE: All structural tolerances given above are for curtain walls (if used) and for all external structural faces of building affecting set out of masonry, windows andother cladding/finishes.

## 6.16 EXTERNAL EXPOSED CONCRETE SURFACE

All external exposed concrete surfaces of cast-in-situ or precast units shall be given smooth or pattern finish as shown in the Drawings schedule or as directed by the Engineer.

## 6.17 MEASUREMENT AND PAYMENT

All costs for formwork must be included in the concrete prices and will not be measured andpaid for separately.

**** END OF SECTION****

## SECTION - 7

## STRUCTURAL STEEL WORKS

### 7.01 SCOPE OF WORK

The work covered by this section consist of general requirement of structural steel work, its fabrication, erection and painting methodology, precautions and other general requirement incidental to structural steel work.

### 7.02 GENERAL

The applicable requirements of this section as determined by the Engineer shall apply to all structural steel works under this Contract. The work covered by this section consists of supply of necessary material, labor, plant, equipment and appliances including welding, bolts, nuts, washers, anchor bolts, embedded parts, etc., fabrication and erection in accordance with the Specifications and as per drawings and as directed by the Engineer.

### 7.03 APPLICABLE STANDARDS

Latest edition of the following standards are relevant to these specifications, wherever applicable:

| | |
|---|---|
| AISC | Code of standard practice |
| AISC | Specifications for Architecturally exposed structural steel |
| ASTM | Specifications for Structural joint using ASTM A325 or A490 bolts. |
| ASTM | Specifications for Material |
| AISC | Specifications |
| SSPC-SP6 | Steel structural council-surface preparation specifications |
| AWS | Specifications for Welding of steel structures |

BS 449 Use of structural steel in buildings

### 7.04 DRAWINGS

#### 7.04.1 Design and Working Drawings

Design and working drawings shall be prepared by the Engineer and shall be suppliedto the contractor. These shall contain main dimensions, sizes of members, and typical details of joints. Forces in members may be specified on the drawings to facilitate design/detailing of connections by the Contractor. However if not specified all connections shall be designed to have full strength capacity equal to that of member being connected.

#### 7.04.2 Shop drawings

Shop drawings shall be prepared by the Contractor from the working drawings taking into consideration the sizes (sections) of members/parts of the structure shall be standard rolled steel sections according to German/British/American or approvedstandards. The contractor, before, tendering, shall prepare material requirement list, ensure its availability at the time of actual fabrication and in case certain sections are not available, he will select suitable available alternatives subject to the approval of theEngineer.

Workshop drawings shall be prepared by taking into consideration the points enumerated below:

i) Fabrication in convenient sub-assemblies and each shop assembly to begiven an erection mark.

ii) Milling (machining of bases of supporting plate) for erection without adjustments.

iii) Provision of basic elements with erection devices.

iv) In-keeping with the requirements of computed strength of all connections and joints of structures not foreseen in the design and in the workingdrawings.

v) Other requirements having an influence on the methodology of fabrication, transportation and erection of steel structures.

vi) Uniformity of elements and parts of the steel structures should be maintained for mass fabrication.

### 7.04.3 Contents of Shop Drawings

Shop drawings shall consist of:

a. An erection scheme drawing having the following information:

- Location of erection elements in respect of axes and marks as well as picking points of these elements with respect to each other or with the existing steel or reinforced concrete structures.
- Erection joints showing erection welding thickness and lengths, bolts or rivet diameter and numbers.
- Chart showing list of assembling marks having columns such as mark, description, quantity, weight of each mark, total weight and remarks with grand total in the end.
- Chart showing list of erection bolts, nuts and washers in tabulated form, showing information such as size, quantity weight and notes and the grandtotal.
- The mark for shop assemblies of each erection scheme shall have a different index, for example scheme of trusses, purlins etc. shall have marks A1, A2, A3 onwards and another scheme of columns, beams etc. shall have marks B1, B2, B3 and onwards. While marking on the plans, elevation, sections and details, the index shall be omitted.
- Except in special cases, all scheme drawings shall be made in single fairly thick lines.
- Erection scheme shall contain the following notes;
- Erection shall be done using the erection welding and bolts of normal sizesand accuracy according to the joints of the scheme.
- Quality and type of electrode.
- Measures against unscrewing of bolts.
- Erection shall be carried out according to the standard for fabrication and erection of steel structures.
- Painting instructions.
- References to design and working drawings.

b) The working drawings shall contain the following information:

- Each Shop Assembly (Mark) shall be drawn separately showing necessary lines, elevations, sections with reference to axis, center lines, location of holes, cleats, plates, lugs, etc. fully dimensioned with part numbers.

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- Bolts, holes sizes and symbols, holes diameter for metric size bolts shall be 2mm larger than bolt diameter and for inch size the same shall be 1/16‖ larger.
- Welding thickness (general)
- Material quality of steel used.
- Type and quality of electrodes to be used.
- Tests for welding, if any.
- Reference to related erection scheme drawings.
- Reference to design and working drawings.
- Material list.

## 7.05 MATERIAL

Except otherwise stated in the drawings, the material specifications shall conform to the following. Wherever necessary the contractor may use equivalent alternative material subject to approval of the Engineer.

### 7.05.1 Structural Steel

Structural steel for structures not requiring welding shall conform to the requirement of ASTM A7 (for bridges and buildings) and ASTM A36.

Structural steel shall conform to the requirement of ASTM A36 or equivalent.

### 7.05.2 High Strength low Alloy Steel

High strength low alloy steel shall conform to the requirements of ASTM A441 or equivalent.

### 7.05.3 Sheet Steel

Steel sheet for structures where no welding is required shall conform to the requirements of ASTM A336 (for cold rolled carbon steel sheets commercial quality) orASTM A415 Standard specifications for cold rolled carbon steel sheets, commercial quality). For structures where welding is required sheet steel shall conform to the requirements of ASTM A425.

### 7.05.4 HD Grade Steel

HD Grade Steel used with vault area reinforcement shall conform to the requirements of ASTM J93005 (ferritic stainless steel)

### 7.05.5 Steel Forging

Steel forgings shall conform to the requirements of ASTM A235 (Tentative specifications for carbon steel forgings for general industrial use) class of forging shall be indicated on the drawings.

### 7.05.6 Steel Casting

Steel casting shall conform to the requirements of ASTM A27 standard specifications for Mild to Medium strength carbon steel castings for general applications) and ASTM A148 (Standard specification for high strength steel castings for structural purposes). Grade of casting shall be shown on the drawing.

### 7.05.7 Filler Metal for Welding

Welding electrodes for manual shielded metal arc welding shall conform to the specifications for mild steel covered Arc-welding electrodes, AWS A5.1 latest edition or the specifications for low-alloy steel covered Arc-welding electrodes, AWS A 5.5 latest edition. Equivalent locally manufactured electrodes may also be used subject tothe approval of the Engineer.

Welding electrodes shall be E70xx. All welding shall be carried out by qualified welder only using approved and qualified welding procedures.

### 7.05.8 Bolts, Nuts and Washers

Unless otherwise specified anchor bolts and nuts shall conform to the requirements of ASTM A307 (Standard specification for low alloy carbon steel) externally and internally threaded standard fasteners). Bolts shall be of grade A for general application.

### 7.05.9 High Strength Bolts

All shop connections, except as noted herein or on the drawings, shall be made with high strength bolts in slip critical connections, or by welding.

High strength carbon steel bolts including nuts and washers shall conform to the requirements of ASTM A325 (Standard specification for high strength bolts for structural steel joints including nuts and plain hardened washers). The dimensions shall conform to the requirements of USASI B18.2965 (square and hexagon bolts and nuts for regular semi-finished hexagon bolts and heavy semi-finished hexagon nuts).

### 7.05.10 Cast Iron

Cast iron shall conform to the requirement of ASTM A48 (standard specifications for gray iron castings).

### 7.05.11 Connections

Unless noted otherwise, all connections shall be designed and detailed for forces shown on the drawings or for 100% of the effective capacity of the member. At least two bolts or equivalent welding shall be used for each connection.

## 7.06 ALLOWABLE STRESSES

Allowable stresses for steel shall be calculated in accordance with AISC specifications for the design, fabrication and erection of structural steel for building.

Allowable stresses for rivets, bolts and threaded parts shall be calculated in accordance withAISC specifications or tabulated allowable loads specified shall be followed.

Allowable stresses for welds shall be calculated in accordance with AISC specification.

## 7.07 FABRICATION

### 7.07.1 Straightening Material

All material, before being worked upon, must be straightened within tolerances by ASTM specifications A6. Straightening necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. Temperature of heated areas, as measured by approved methods, shall not exceed 1100 F for A514 steel or 1200 F for other steels.

### 7.07.2 Cutting

As far as possible, cutting must be done by shearing. Oxygen cutting shall be done where shear cutting is not possible and shall preferably be done by machine. All edgesshall be free from gauges, notches or burs. If necessary, the same shall be removed by grinding.

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### 7.07.3 Holes Punching Drilling

Holes may be made by drilling or punching. Holes shall be punched where thickness of the material is not greater than the diameter of bolt + 3mm. where the thickness of the material is greater, the holes shall either be drilled or sub-punched and then reamed to size. The die for all sub-punched holes and the drill of all sub-drilled holes shall be at least 2mm smaller than the nominal diameter of bolt. Holes for A 514 steel plates over ½‖ thick shall be drilled.

### 7.07.4 Welding

a. **General:** The execution and inspection of welding shall be done in accordance with the provisions of the American welding society code/Specifications for welding in building construction, D1.0.

b. **Automatic Sub-merged Arc Welding:** For all build-up members, i.e. sections fabricated from plates and flat bars or compound rolled sections and plates, wherelong continuous, welding is to be done, should be executed by Automatic submerged arc welding process in accordance with relevant AWS specifications.

c. Maximum and minimum size and lengths of fillet welds shall be done in accordance with AISC specifications.

d. Surface to be weld shall be free from loose scale slag, rust, grease, paint or any other foreign matter except mill scale, which withstands vigorous wire brushing.

### 7.07.5 Tolerances

A variation of 1mm is permissible in the overall length of members with both ends finished for contact bearing. The bearing surface is to be prepared to a common plane by milling. Members without end finished for contact bearing, which are to be framed to other steel parts of the structure, shall have a variation from detailed length not greater than 3mm.

### 7.07.6 Test Assembly

Fabricated shops assemblies of all components shall be test assembled together after fabrication, prior to painting/galvanizing.

Test assembly work and procedure should be planned during fabrication process. Major fabrication work of locating of gussets etc. marking and drilling of holes for inter connecting joints, spliced connection leveling, placing of bracing, should be done simultaneously with test assembly.

Each test assembly will be inspected by the Engineer's representative and shall be dismantled only after his approval in writing.

## 7.08 SURFACE PREPARATION/PAINTING/GALVANIZING

### 7.08.1 Surface Preparation for Painting and Coating:

- After fabrication and test assembly the surface preparation for painting or coating of all components shall be done conforming to SSPC - SP10 (near white metal)by means of sand blasting.
- The sand used for this purpose shall be free from earth, dirt, clay and moisture.
- The size of sand particles, air pressure and size of the hose nozzle shall be correlated to give a proper and acceptable surface.

### 7.08.2 Painting

Painting of all steel, forged or cast components shall be done in 5-coats as under:

- Surface Preparation:
- Near white metal surface according to SSPC SP-10.
- First and Second Coat:

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- Two pack anti corrosive Epoxy primer of 50 microns dry film thickness for eachcoat.
- Third, Fourth and Fifth; Finishing Coat:
- Two pack Epoxy resin enamel pigmented suitably for resisting highly corrosiveand chemical influences and for withstanding abrasion and erosion.
- Each coat shall have 50-micron dry film thickness.
- Paint Selection/application
- Paints of manufacturers of repute shall be selected. The complete 5-coat paint system of any one of the manufacturers shall be used.
- The application of each coat of paint shall be done in accordance with the paint manufacturers recommendations, printed in their authentic printed catalogue.

### 7.08.3 Engineer's Approval:

The contractor shall submit 2 or more proposals containing the following for Engineer's approval:

1. Manufacturers name along with authentic painted catalogue.
2. Relevant 5-coat paint system with manufacturer trade names.
3. Any other details of relevance.

### 7.08.4 Steel Work/Surface not to be Painted

i) Steel work to be encased / embedded in concrete or surface in contact with concrete or grout shall not be painted, but shall be given a cement wash after sand blasting.

ii) Machined finished surfaces shall not be printed but shall be coated with rust preventive compound, approved by the Engineer immediately after finishing. Such surfaces shall be also protected with wooden pads or other suitable means for transportation. Unassembled pins, keys, and bolt threads shall be greased and wrapped with moisture resistant paper.

iii) Contact surfaces of connections using high strength bolts in friction type connections shall not be painted. Such surfaces of all components afterfabrication shall be cleaned free of paint, grease, burrs slag by means of sand blasting. No coating whatsoever then be applied to such surface.

### 7.08.5 Zinc Coating (Galvanizing)

Components shall be galvanized after complete fabrication i.e. welding, drilling etc. The process should consist of removal of rust and mill scale by pickling in hydrochloric acid or sulphuric acid followed by water wash and prefluxing with ammonium chloride. The fluxed components should then be passed through a drying oven prior to immersion in a bath of virtually pure molten zinc.

The zinc coating shall be applied in a manner and of a thickness and quality conforming to the requirements of ASTM A123, standard specification for zinc (hot galvanized) coating on products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.

## 7.09 INSPECTION AND TESTS

Manufacturer's work test certificate for all material used shall be furnished by the Contractorfor Engineer's scrutiny and approval.

a. Rolling tolerance of all shapes and profile shall be in accordance with the provisions of the American Society for Testing and Material Designation A.6. These shall be checked by the contractor before being worked upon and shall be rejected if found not within limits.

b. The contractor shall arrange for analysis and test of all material rolled locally at a testing laboratory selected by the Engineer.

c. Nevertheless, neither the fact that the material have been tested nor that the manufacturers work test certificates have been furnished, shall effect the liberty of the Engineer to reject, after delivery, material found not according to these specifications.

## 7.10 ERECTION

### 7.10.1 Bracing

The framing of steel skeleton buildings shall be carried up true and plumb within the limits defined in Section 7(h) of the AISC code of standard practice, and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subjected including the equipment and the operation of the same. Such bracing shall be left in place as long as required for safety.

### 7.10.2 Alignment

No riveting, permanent bolting or welding shall be done at site during erection until as much of the structure as will be stiffened thereby has been properly aligned.

### 7.10.3 Joints using High Strength Bolts

All structural joints using high strength bolts shall be executed and inspected in accordance with ¯AISC specification for structural joints‖ using ASTM A325 or A490 bolts.

## 7.11 MISCELLANEOUS STEEL WORK

### 7.11.1 General

The work covered shall include furnishing, fabricating, painting and installing miscellaneous steel work including the following:

a. Steel Stairs
b. Steel Ladders
c. Steel Pipe handrails
d. Steel protection angles
e. Steel doors, windows, gates, ventilators/louvers.
f. Steel fencing.
g. Grating and chequered plate covering.
h. Embedded plate, anchor bolts and other miscellaneous items.

### 7.11.2 Steel Stairs

General: Structural steel stairs complete with grating treads or chequered plate treads, landings, supporting structures, handrail, supports etc. shall be furnished and installed in accordance with working drawings. All components shall be galvanized to maximum extent practicable as shown on the drawings.

Material: Except otherwise indicated in the working drawings materials shall conform to the requirements of ASTM A36 (Tentative specifications for structural steel).

### 7.11.3 Steel Ladders

Steel ladder shall be welded assemblies with or without safety cages fabricated in accordance with the drawings. Material and standard of fabrication shall be the same as specified for stairs.

### 7.11.4 Steel Pipe handrails

Steel pipe handrails consisting of posts, handrail, knee rails and toe rail shall be fabricated in suitable units having two posts or three posts in one unit with erection joints between handrail and knee rails. Handrail of platforms galleries etc. of considerable length may not be shop fabricated as complete units consisting of posts etc. in case of such handrails the posts may be fabricated of the required height having one end with

necessary arrangement for fixing to the platform or floor beams etc. and other end shop prepared to take the top handrail. Top handrail, knee rail and tow rail may be brought at site in stock length. The same may then be cut and welded at site. Locally manufactured pipes, M.S. or G.I may be used for the hand railing. These shall however conform to the requirements of ASTM A53 or shall be of equivalent requirements.

### 7.11.5 Steel Protection Angles

Steel protection angles required for the protection of concrete work shall be erectedtrue to line and level. Steel angles shall be fixed in position by using anchors.

### 7.11.6 Steel door, windows, ventilators, louvers and gate frames:

Frames shall be fabricated form locally available hot rolled angle, tee, channel or pipe sections as specified in the drawings. Material shall however conform to ASTMA36.

**Shutters:**
Shall be made of any of the sections noted above with skin plate of at least 18 S.W.G as shown in the drawings.

Accessories such as hinges, anchors, bolts, locks and handles shall conform to the requirements shown on the drawings or as directed by the Engineer.

### 7.11.7 Steel Fencing

Steel fencing shall be made from wire mesh bolted on the steel angles or channel frame as shown on the drawings or as directed by the Engineer.

Surface Preparation and Painting.

Surface preparation painting and galvanizing of all miscellaneous steel work shall be done in accordance with clause 10 herein.

## 7.12 MEASUREMENT AND PAYMENT

### 7.12.1 General

Except otherwise specified herein or elsewhere in the contract documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

a. Bolts, nuts, washers, screw, rivets, heads, fillets, welds and welding rods.
b. Galvanizing and painting.
c. Glass and glazing.
d. All embedded parts unless otherwise specified in the Bill of Quantities
e. Painting
f. Steel grills and fly proof of shutters
g. Locks, handle, hinges, hold fast, stopper etc.

### 7.12.2 Structural Steel Works and Miscellaneous Steel Work

**Measurement**
Item of work of structural steel for which the unit rates have been quoted on weight basis and for which detailed workshop drawing have not been made shall bemeasured net as installed at site as per sketches and instruction of the Engineer. After measurement the theoretical weight shall be calculated from standard tables of section and weight in the manner followed in the preparation of shop drawings.

Items of works of structural steel for which the unit rates have been quoted on weightbasis and for which the detailed shop drawings have been prepared, measurement shall be made at site to verify whether the items fabricated, supplied and erected in position are in

conformity with the shop drawings. If the same is so verified to the satisfaction of the Engineer the weights given in shop drawing shall form basis of payment of bill. Any deviation found during the verification the same shall be checked from design and specifications point of view and shall be incorporated in the shop drawing and consequently the weights shall be revised.

**Payment**

Payment shall be made for acceptable measured quantity of all structural steel works on the basis of unit rate quoted in the Bill of Quantities and shall constitute full compensation for all the recovery related to the item.

### 7.12.3 Steel Embedded Part

**Measurement**

Measurement of acceptable completed works of steel embedded parts will be madeon the basis of weight of steel parts provided and embedded in position as shown onthe drawings or as directed by the Engineer.

**Payment**

Payment shall be made for acceptable measured quantity of steel embedded parts on the basis of unit rate per metric ton quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the items.

**** END OF SECTION****

## SECTION - 8
## CEMENT CONCRETE BLOCK MASONRY WORK

### 8.01 SCOPE OF WORK

The Work covered by this section of the Specifications consists of all work required in connection with construction of block masonry portions of structures and partition walls including but not limited to furnishing of precast solid or hollow cement concrete blocks, cementmortar, all related items and appurtenances including all items supplied by other trades and customarily built-in and installed under masonry work or required to complete masonry work, all labour, plant, tools, scaffolding, hoisting equipment and all other materials, and in performingall operations in connection with block work, i.e., erecting, placing, bedding, building in, curing and protecting all masonry works, complete in accordance with requirements of Drawings, Bill of Quantities, Specifications as stated herein, and to the entire satisfaction of the Engineer andsubject to the terms and conditions of this Contract.

### 8.02 MATERIALS

#### 8.02.1 Portland Cement

All Portland cement for concrete block and mortar shall conform to the stipulations and requirements specified in ―Section 4 – Specifications of Plain and Reinforced Concrete‖.

#### 8.02.2 Sand and Coarse Aggregates

All sand and coarse aggregates for the cement concrete blocks and sand for mortar shall be obtained from approved quarries and shall conform to the requirements specified herein below:

a. Sand

Sand shall be clean, and shall be of the same quality as the sand obtained from approved quarries for concrete works. It shall be hard, strong, durable, soft and free from flaky particles, injurious amounts of dust, alkali, organic matter or other deleterious substances and shall comply with all the requirements for concrete. The Contractor will be required to screen and wash the sand to remove any foreign matter in it. The sand or fine aggregate shall be graded as specified in the section on concrete or in the manner approved by the Engineer.

Coarse Aggregate

Coarse aggregate shall be gravel obtained by screening the gravel or hard crushed stone and shall comply with the requirements for aggregates for concrete. The Contractor shall screen the aggregate through 9 mm and 5 mmsieve as many times as may be necessary to obtain such material as shall be retained on the 5 mm sieve. The grading shall be approved by the Engineer and may be modified if required. A representative sample of the aggregate collected by the Contractor from time to time shall be tested by the Engineer and if the sample would not conform with the approved grading as required bythe Engineer, the entire gravel collected by the Contractor will be liable to be rejected.

The aggregate shall be free from soft, friable, porous, flaky, elongated or laminated pieces. The aggregate shall also be free from dirt, silt, clay, shale, alkali or organic matter. It shall be sufficiently strong to utilize the full strength of cementing material.

### 8.02.3 Water

Water used for making concrete blocks, mortar, laying of masonry, or any other operation of constructions shall be potable water free from objectionable quantities of silt, organic matter, alkali, salts and other impurities and shall comply with the requirements of water for mixing and curing of concrete and shall be tested and approved by the Engineer.

### 8.02.4 Admixtures

a. Mortar plasticizers shall comply with the requirements of BS 4887.

b. Admixtures used in the manufacture of blocks shall comply with BS5075.

### 8.02.5 Mortar

Pre mixed mortars shall comply with the general requirements for materials and mix proportions shall be as given in this Specification.

### 8.02.6 Damp-Proof Course

Flexible damp-proof course materials shall comply with BS 743 where applicable and shall comprise of the following:

i) bituminous roofing felt not less than 3 mm thick, or
ii) polyethylene sheeting not less than 0.5 mm thick or
iii) any other approved material

The damp-proof membrane shall be laid on an even bed of cement sand mortar (1:1) and lapped 6‖ at all joints. The damp-proof membrane shall cover the full width of the blocks.

### 8.02.7 Bonding Ties

Bonding Ties shall be expanded metal strips as shown on the Drawings or as directedby the Engineer.

### 8.02.8 Wall Ties

Wall ties shall comply with BS 1243 and shall be hot dip galvanized steel as approved by the Engineer.

## 8.03 PROPORTIONING OF INGREDIENTS

The blocks will be made using a concrete mix of 1:3:6 cement, Sand and aggregate.

## 8.04 MAKING OF CONCRETE BLOCKS

8.04.1 All solid and hollow blocks shall be machine moulded of required sizes as shown on Drawings and approved by the Engineer and shall generally conform to the requirements of British Standard 2028, 1346:1968 ―Precast Concrete Blocks‖ unless specified otherwise. The ingredients shall be well worked into the moulds, vibrated, tamped and pressed to ensure that the blocks are dense and free from voids.

8.04.2 In case of the hollow blocks, the cavities shall be true to the shapes and sizes specifiedand shall have uniform wall thickness on the outside of the cavities. The cavities in hollow blocks shall not be more than 25% of the total volume.

8.04.3 For casting, the moulds shall be placed on a level platform cast from 2‖ thick 1:3:6 concrete. The finished blocks shall be true to shape i.e. every face shall be perfect rectangle exactly parallel to the opposite face and exactly perpendicular to the adjoining faces. All the blocks

shall be free from cracks, spalls, chips, rugged edges or other defects detrimental to their use. Blocks with broken edges or which are skew willnot be allowed to be used on the Work and must be removed from the Site of Work within 24 hours of their being rejected.

8.04.4 The blocks must not be lifted from the platform till they have been cured for a period of 2 days in addition to 10 hours required for setting. After 2 days the blocks must be removed and stacked to reasonable height as directed by the Engineer. The block stacks are to be kept wet for a period of 8 days and then shall be allowed to dry in shade for at least twenty (20) days before they are used in the Work. The blocks cast on different dates must be separately stacked. The date of casting and number of blocks in each stack shall be properly marked with non-washable paint.

8.04.5 The average compressive strength of any five solid blocks at random shall be not less than 1000 pounds per sq. inch.

8.04.6 The average moisture content of all the concrete masonry units shall not exceed 30% of the total water absorption of units. The shrinkage of cement concrete blocks is much greater at the time it dries for the first time after moulding and subsequent curing. It is, therefore, essential that the Contractor shall take full care to see that blocks are sufficiently and thoroughly dried so that their initial shrinkage is completed before the blocks are laid in the Works. Not only well dried blocks shall be used, but the blocks shall also be laid dry without wetting except with slightly moistened surfaces on which mortar is to be applied to obviate absorption of water from the mortar and even during curing of the mortar joints. The walls shall be slightly moistened and shall not be allowed to be excessively wet till they receive any plaster or render.

8.04.7 The blocks shall be stored in such a manner as to avoid any contact with moisture on the Site of Works. The blocks shall be stock piled on platforms or other supports free from contact with the ground. If necessary, cover for protection against wetting shall beprovided. The blocks right from casting to curing, drying, stock piling and their subsequent placing in masonry walls shall be handled with care.

## 8.05 MORTAR

8.05.1 All mortar for masonry shall be in proportion of one part of cement to six parts of sand (fine aggregate) or as directed by the Engineer. The ingredients shall be mixed by volume in purpose made gauge boxes. All mortar shall be mixed in a mechanical mixers. Hand mixing, when permitted by the Engineer shall be done on clean, hard platform of only such quantities as required for immediate use with just sufficient waterto produce mortar of stiffest consistency and sufficient workability.

8.05.2 Cement shall be Portland cement as specified under the section ¯Plain and Reinforced Concrete‖ as per BS 12.

8.05.3 Fine aggregate (sand) shall be clean, hard, durable, soft and free from flaky particles as specified herein above shall be subject to the approval of the Engineer. Mortar shallbe mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of water to the mix shall be rejected. Re-tempering of mortar will not be allowed.

8.05.4 The dry materials (cement and sand) shall be dry mixed for approx. two (2) minutes and for three minutes after addition of water making total minimum time of five (5) minutes in a mortar mixer. When hand mixing is permitted, dry mix, rake well, turn overmaterials for each batch before adding water, until uniform colour of mixed materials indicated through distribution of cementitious material. After dry mixing is complete, add water until the correct consistency is obtained.

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The sand shall meet the following B.S. Specifications:

a. Sand for mortar shall comply with the requirements of BS 1200.

b. The grading of sand for general purpose mortars shall be within the limits of Table 1 of BS 1200. The grading of sand for reinforced block work mortars shall be within the limits of Table 2 of BS 1200.

c. The clay/silt content, when determined in accordance with BS 812, shall not exceed 3%.

d. The Chloride and Sulphate contents shall not exceed the limits given inaggregates for concrete.

## 8.06 LAYING OF BLOCK MASONRY

8.06.1 All block work shall be set out and built to the respective lengths, dimensions, thickness & heights shown on the Drawings.

8.06.2 All block work should be true to lines, plumb and level. Chases, grooves, raglet block and raked out joints shall be kept free from mortar and debris.

8.06.3 Block work shall be carried up in a uniform manner, no one portion being raised more than 3 ft. above another at one time unless special circumstances render this impracticable. All perpends, quoins etc. shall be kept strictly true and square and the whole properly bonded together. The maximum height which is to be built in one dayis 5 ft.

8.06.4 All horizontal and vertical joints shall be completely and solidly filled with mortar as andwhen the blocks are laid.

The thickness of joints shall generally be ½‖ and at no point more than 5/8‖. All crossjoints shall also be filled well.

8.06.5 Any mortar which falls on the floor from the joints or removed due to raking of joints shall not be reused and must be cleaned and removed from Work-Site at the end of the day.

8.06.6 Where masonry abuts R.C.C. columns or walls, it shall be anchored thereto by means of 3/8‖ diameter bars at a vertical spacing of 16‖ and as shown on the Drawings or as instructed by the Engineer.

8.06.7 Masonry shall be cured for at least ten (10) days from the day it is laid.

8.06.8 Mortar already spread which becomes diluted by rain shall be removed and replaced before continuing with the work.

8.06.9 Hollow blocks where used shall be placed in a manner as shown on the Drawings and/or as directed by the Engineer.

8.06.10 Block walls shall be built in stretcher bond, accurately special with each breaking joints with the course below. Intersections of block walls shall be properly bonded in alternative courses.

8.06.11 Generally, blockwork where exposed shall be flush jointed as the work proceeds. Joints of those facings which are to receive external or internal plastering shall be raked out ¾‖ deep when the mortar is still fresh so as to provide proper bond for the plaster.

8.06.12 All hollow blocks shall be filled at sides of openings and intersections with concrete mix having a compressive strength at 28 days of not less than that of the block.

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8.06.13 A solid or pre-filled course of blockwork shall be provided at sill level of openings and under bearing of all in situ concrete.

8.06.14 Pointing of exposed blockwork shall be as shown in the Drawings or as directed by the Engineer. Pointing shall be done as the work proceeds.

8.06.15 Unless otherwise shown on the Drawings or specified, the spaces around frames and other built-in-items shall be solidly filled with mortar, except the joints that are to be caulked shall be raked out ¾‖ deep.

8.06.16 Work required to be built in with masonry including anchors, wall plugs and accessories shall be built in, as the work progresses. Wood plugs and blocking shall not be built into masonry.

8.06.17 No masonry to be erected when temperature of outside air is below 40°F unless suitable means as approved are provided to heat material protected from cold and frost and ensure that material will harden without freezing.

8.06.18 When the masonry is to receive plaster on one side and pointing on the other, the blockshall be placed in such a way that the better face shall be on the side of pointing.

## 8.07 COORDINATION

8.07.1 The Contractor shall provide chases and openings in block work required under other sections to sizes and locations as shown in the Drawings.

8.07.2 The Contractor shall cooperate with other trades in setting built-in items, take special care in cutting, fitting, setting units so that built-in members are in their true, respectivepositions.

8.07.3 The Contractor shall also coordinate during blockwork for the items provided in other sections such as door frames, hold fasts, miscellaneous metal work occurring in the masonry and sleeves, anchors, supports, nailing strips, braces, jambs etc. to be built- in the masonry.

8.07.4 Special care shall be taken in building walls of door frames. Contractor shall see that frames are square and in plumb. Check frames before building blockwork around or against them. The Contractor shall see that electric conduits are not housed into frames so as to prevent extension of frame anchors.

8.07.5 The Contractor shall be responsible for any damage or abortive work due to lack of coordination on his part or due to negligence of his Site supervisory staff in coordination of various sections of Works and no compensation shall be made to the Contractor on such account. The Contractor shall reinstate/make good such affected works at his own cost.

## 8.08 PROTECTION AND CLEANING

8.08.1 Surface of masonry not being worked on shall be properly protected to all times during the construction operations. When rain is expected and the work is discontinued, the top of exposed masonry walls shall be covered with a strong waterproof membrane, well secured in place.

8.08.2 Exposed masonry surfaces shall be cleaned with water and fiber brushes or as directed by the Engineer.

8.08.3 Protect adjacent work during cleaning operations. Make good any damages from neglect of this account.

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## 8.09 SAMPLES

Samples of all kind of materials to be used on the job shall be submitted to the Engineer and to be approved by him before quantities are procured for the Works. Source of supply or quality or materials not be changed unless authorized in writing by the Engineer.

## 8.10 TESTING

All the materials and completed masonry work shall be subjected to standard testing and if found below the Specifications and BSS or ASTM standards, shall be rejected. Rejected material shall be removed from the Site immediately at the Contractor's expense. All testing shall be done at the Contractor's cost.

## 8.11 CONCRETE LINTEL BEAM

Unless otherwise indicated, provide concrete lintel over openings in the concrete masonry unitwalls and partitions. Lintels shall be of the size and shall be reinforced as indicated. All lintel shall be as-in place and when exposed shall be the same color, surface texture and finish as the adjacent walls or partition. Concrete work shall conform to section 4 of this specification.

## 8.12 MEASUREMENT AND PAYMENT

Masonry Works in accordance with this section of Specifications shall be measured and paid for per square Meter/feet wall of a thickness as specified in the Drawings and Bill of Quantities complete and approved including mortar as specified, preparations, tests etc. but excluding cost of blocks which shall be supplied by the Employer. Openings of more than 0.28 sq.m shall be deducted. Damp-proof course shall be measured and paid for separately.

Steel anchors/wall ties for connection to R.C.C. or steel columns are deemed to be included in the above rates and will not be paid for separately.

Cuttings for conduit/pipe installations, anchors, fixing of other installations, embed items, fittings & fixtures are deemed to be included in the relevant items and will not be paid for separately.

**** END OF SECTION****

# SECTION - 9
# PLASTERING AND RENDERING

## 9.01 SCOPE OF WORK

The Work covered by this section of the Specifications consists of furnishing all plant, labour, appliances/ equipments and materials for performing all operations in connection with lathing, plastering and rendering, complete in all respect; in strict accordance with this section of the Specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

## 9.02 APPLICABLE STANDARDS

Latest editions of following Pakistan, British & ASTM standards are relevant to these specifications wherever applicable.

**Pakistan Standard**
PS 232 Ordinary Portland Cement

**ISO (International Organization for Standardization)**
R 597 Definitions and terminology of cement.

R 679 Method of testing strength of cements, compressive and flexural strength of plastic mortar (Rilem - Embureau method).

R 680 Chemical analysis of cement& main constituents of Portland cement.

R 681 Chemical analysis of cements-mixer Constituents of Portland cement.

R 682 Chemical analysis of cements - determination of Sulphur as Sulphide.

**ASTM (American Society for Testing and Material)**
C 144 Aggregate for Masonry mortar
C 631 Bonding compounds for interior plastering

**BSI (British Standards Institution)**
812 Methods for sampling and testing of mineral aggregates, sands and fillers.

1199 Sands for external renderings internal plastering with lime and Portland cement and floor screeds.

1369 Metal lathing (steel) for plastering.

5262 External rendered finishes.

5492 Internal plastering.

## 9.03 GENERAL

Except as may be otherwise shown or specified, all interior & exterior plaster shall be cement plaster in specified thickness shown on Drawings & BOQ. Plastered ceilings and walls shall include partitions, piers, columns, beams, ceilings, plastered jambs and other returns, reveals,and backs of recesses and alcoves, and joints and heads of windows and doors, unless otherwise specified or shown on the Drawings. Plaster on walls shall be carried down to dado, skirting and projected bases. Plasterwork shall also include all plasterwork on and under concrete surfaces and masonry. Concrete surfaces to be left exposed and concrete not specified to be left fair faced, as indicated on Drawings.

A 3/8‖ render coat shall be applied to walls with a slightly roughened surface where wall finishes of applied nature, such as ceramic tiles, marble tiles, granite tiles, textured paint etc., are to beinstalled over wall surfaces.

Plastering shall not commence until all electric conduits, drainage and sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are fixed in position. It shall be the responsibility of the Contractor to make sure that other contractors carry out all such work before starting of plasterwork. Chiseling and repairing of cement plaster shall not be permitted without the approval of the Engineer.

## 9.04 MATERIALS

a. Cement for plaster shall be Ordinary Portland Cement (BS 12 or PS 232) or Sulphate Resisting Cement (BS 4027 or P.S. 612) as specified and shall conform to requirements specified in the section "Plain and Reinforced Concrete".

b. Sand for plaster shall comply with the requirements of BS 1199, BS 1200, ASTM C-33 and/or the Pakistan Standard "Sand for Plaster" as directed by the Engineer.

c. Water shall be clean and free from oils, acids, alkalis, salts and organic or other injurious matter and as described in section for "Plain and Reinforced Concrete".

d. All materials and workmanship for plaster not explained in these Specifications, shall comply with the requirements of relevant BS CP 211 and CP 221 as directed by the Engineer.

e. External rendered finishes should comply with appropriate clauses of BS 882.

f. Mortar plasticizer shall comply with BS 4887 and shall be used in accordance with the manufacturer‘s instructions.

g. Pigments to be used shall comply with BS 1104.

h. Galvanized metal angle beads and plaster stops shall be as manufactured by the Expanded Metal Co. Ltd., London or other equal and approved.

## 9.05 MIXING OF PLASTER

Measurement of materials by volume shall be by containers of known capacity to maintain consistent proportions. No lumpy or caked material shall be used. Mixing equipment boxes andtools shall be clean. Materials shall be proportioned as specified on the Drawings or as directed by the Engineer. Mixing shall be continuous until all ingredients are evenly distributed and thoroughly mixed. Only limited water shall be added for proper workability and such quantity ofmortar shall be prepared which can be consumed in thirty minutes after preparation. Preparation of mortar in bulk quantity for use during the entire day or for any other time more than that stipulated above is expressly prohibited. Re-tempering shall not be permitted and all mortar, which has begun to stiffen, shall be discarded.

Except where hand mixing of small batches is approved by the Engineer, mechanical mixersof an approved type shall be used for the mixing of plaster. Frozen, caked, or lumped materialsshall not be used. Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with the proper amount of water until uniform in colour and consistency.

Re-tempering will not be permitted, and all plaster which has begun to stiffen shall be discarded. Plaster ingredients shall be thoroughly mixed either by hand on a clean cement concrete platform or by a mechanical mixer, as directed by the Engineer.

Water Proofing Plaster 3/4 inch. (20mm) thick 1:4 cement sand plaster mixed with approved water proofing agent.

Re-tempering will not be permitted, and all plaster which has begun to stiffen shall be discarded.

## 9.06 PROPORTIONING OF PLASTER ON INTERNAL AND EXTERNAL WALLS

All plaster shall be Portland cement plaster, all coats of which shall be mixed in the following proportions by volume:

- One part cement and 4 parts sand or specified otherwise.
- One part cement and 3 parts sand only for RCC roof slab soffits.

All coats of plaster in water retaining structures shall be waterproofed by the addition of an approved waterproofing additive/admixture from BCR, Sika, Fosroc, Betocrete C-16or Master Builders or approved imported equivalent.

External plaster shall be pigmented plaster in the shades/ colors to the approval of the Engineer.

## 9.07 PREPARATION OF SURFACES OF PLASTER

a. Surfaces to receive plastering shall be brushed to remove all loose particles, dust, laitence, efflorescence, etc. and any projecting fins on concrete surfaces shall be hacked off.
b. Glossy or greasy surfaces shall also be suitably cleaned and chipped off to remove all traces of mould oil.
c. Where unduly smooth in-situ concrete surfaces are encountered, such surfaces must be hacked properly before applying plaster.
d. Surfaces shall thoroughly be sprayed with water and all free water allowed to disappear before plaster is applied.
e. Irregularities in the surfaces to be plastered shall be filled with cement mortar 24 hours before plastering is commenced.
f. Before plastering is commenced, all junctions between differing materials shall be reinforced. This shall apply where walls join columns and beams particularly where cracks are likely to develop and places directed by the Engineer. The reinforcement of such jointsshall consist of a strip of galvanized expanded metal lathe/mesh, at least 6‖ wide, which shall be plugged, nailed or stapled to the surfaces to be plastered at the intervals not exceeding 12‖. The joints in mesh shall be lapped minimum 6‖.
g. Metal angle beads shall be fixed with plaster dabs at 24‖ centers applied to the wall on either side of the arise and the wings of the beads pressed well in.
h. The Plaster stops shall also be fixed in a similar manner or plugged, nailed or stapled to the surfaces to be plastered to the approval of the Engineer.
i. Metal angle beads and plaster stops shall be fixed at places shown on the Drawings or as directed by the Engineer.
j. It shall be responsibility of the Contractor to ensure that all electrical conduits, pipes, concealed or embedded items, ducts, brackets, doors, window and ventilator frames, and all other fixtures on walls, ceilings, columns or required elsewhere have been fixed in position before the plastering is commenced.
k. Cuttings and chasings in the block work shall be repaired as per the instructions of the Engineer at least twenty four hours before the plastering is commenced.

## 9.08 APPLICATION OF PLASTER

The Contractor shall not start any work till the surfaces are inspected by the Engineer. In case, any plaster work is done without obtaining the consent of the Engineer, the Engineer shall have the right to order removal of all such work and cleaning and preparation of the surfaces to his full satisfaction and the Contractor shall comply with such orders without any delay.

All surfaces to be plastered shall be treated with cement slurry as a base coat for proper bond. Any approved bonding agent may also be used as an alternative to cement slurry.

Plaster to internal and external surfaces shall be applied in the thickness shown on the Drawings or specified elsewhere. In any case, the plaster thickness shall not be less than the specified thickness.

Plaster shall be applied in two (2) coats on masonry and concrete surfaces where thickness ismore than 3/4‖. The thickness of each coat shall not exceed 3/4‖.

a. In case of 2 coats, the first coat or the under coat shall be full and thick and shall be applied with sufficient force to form good keys. The under coat shall be roughened and cross-scratched upon attaining its initial set to provide a proper bond to the next coat and shall be kept damp with a fog spray.
b. Finish coat shall not be applied until the under coat has seasoned for 2 days. Just before application of the finish coat, the under coat shall again be wetted evenly with a fog spray.
c. Finish coat shall be smooth finished.
d. The finish coat shall be kept moist with a fog spray for at least 2 days and thereafter shall be protected against rapid drying until properly and thoroughly cured.

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Plastering shall be executed in a neat workmanlike manner and shall be finished off with a wood or steel float, straight and plumb and shall not have wavy surface. The surface shall be of even texture and entirely free from all marks. The edges and corners shall represent a straight line. All the arises shall be rounded to 6 mm radius unless otherwise specified.

Plastering shall neatly be made good around pipes or fittings.

As far as practical, plastering shall not be commenced until all mechanical, electrical and plumbing items, conduits, pipes, fittings and fixtures have been installed in their sequence of operations.

Plaster is to be maintained in moist condition for at least four days after it has developed enough strength not to be damaged by water.

Plaster stops and angle beads of expanded metal shall be used for protection of arises, edges and plaster ends as shown on the Drawings and as directed by the Engineer.

Plaster containing cracks, blisters, pits, discoloration or any defects shall not be acceptable. Any such defective plaster rejected by the Engineer shall be removed and replaced in conformity with these Specifications by the Contractor at his own cost to the satisfaction and approval of the Engineer.

## 9.09 SAMPLING OF PLASTER

Samples may be taken by the Engineer at any time from plaster work in place. Areasrepresented by samples which show over sanding will be rejected.

## 9.10 PATCHING

Plaster containing cracks, blisters, pits, checks, or discoloration will not be acceptable. Such plaster shall be removed and replaced with plaster conforming to this Specification and approved by the Engineer. Patching shall match with existing work in texture and colour.

## 9.11 CONCRETE / MASONRY JOINTS

All joints of concrete and block walls shall be specially treated as described here or as shown on Drawings. A 150 mm wide approved expanded metal shall be fixed at the joints and then plaster shall be applied. The expanded metal shall be with a weight of 3.0 lbs./sq. yd.

## 9.12 CLEANING AND PROTECTION

Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Engineer. As each room or space is completed al! Rubbish, debris, scaffolding and tools should be removed to leave the room clean.

Prior to plastering all aluminum windows, finished metals should be covered by sheet of plastic or tarpaulin to protect it from damage.

Protect finished plaster from injury by any source. Contractor shall also protect walls, floors and work of other trades from plaster materials.

## 9.13 TOLERANCES

The work shall be carried out while maintaining the following tolerances:

- Surfaces of plaster work shall be finished with a true plane to correct line and level unless otherwise specified and with walls and reveals plumb and square.
- Maximum permitted tolerances shall not exceed 1/8 inch (3mm) in 6ft. (2 meter), but not exceeding 12 mm, maximum over the length of the building.
- Variation from plumb or level in any exposed line or surface and 1/16 inch (1.5 mm)

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- Variation between planes of abutting edges or ends 1/16 inch (1.5 mm)
- Maximum permissible Offset at joints is1.5 mm maximum

## 9.14 MEASUREMENT AND PAYMENT

Plaster shall be measured and paid per square Meter/feet, complete and approved, at the unit rates entered in the Bill of Quantities, including preparations, junction reinforcements, angle beads, plaster stops, framing and metal furring, metal lathe, chamfered edges, rounding off corners etc. and in the thickness as specified in Bill of Quantities.

**** END OF SECTION****

## SECTION - 10

## CARPENTRY AND JOINERY

### 10.01 SCOPE OF WORK

The work covered under this section of Specifications consists of providing all material, labor, plant, equipment, appliances and performing all operations connected with the fabrication and erection of all woodwork, mill work, construction assembly, surface finish treatment and building in of all cabinet type items, supports etc. of wood or metal and incidentals, associated woodwork appurtenances, procuring and applying preservatives, installation of "Finish Hard Ware" in connection with finish woodwork as per details shown on the Drawings or as directed by the Engineer. The scope of this section is covered with detailed specifications as laid down herein.

### 10.02 APPLICABLE STANDARDS

Latest editions of following British and ISO Standards are relevant to these specifications wherever applicable.

**ISO (International Organization for Standardization)**

1891 Bolts, screens, nuts and accessories-Terminology and nomenclature.

1097 Plywood - Measurement of dimensions of panels.

1098 Veneer ply wood for general use-General requirements.

2427 Veneer ply wood with rotary cut veneer for general use-Classification by appearance of panels with outer veneer of beech.

2429 Ply wood - Veneer ply wood with rotary cut veneer for general use-Classificationby appearance of panels with outer veneers of brand leaved species of tropical Africa.

3804 Ply wood-Determination of dimension of test pieces.

3805 Ply wood-Determination of density.

3806 Ply wood-Determination of moisture content.

6442 Door leaves-Measurement of defects.

6443 Door leaves-Measurement of dimensions and of defects of squareness.

6444 Door leaves-Test of behavior under humidity variations.

**BSI (British Standards Institution)**

459 Wooden doors.

1186 Quality of timber and workmanship in joinery.

1127 Hinges

1331 Builder's hardware for housing.

1567 Wood door frames and linings nails.

1202 Nails

1203 Specifications for synthetic resin adhesive for plywood.

1204 Synthetic resin adhesives for wood.

1282 Guide to choice, use and application of wood preservatives

1494 Fixing accessories for building purposes.

1579 Connectors for timber.

3842 Treatment of ply wood with preservatives.

## 10.03 MATERIALS

### 1. Timber

Common Timber shall be sub divided into following:-.

- **Hardwood 1st Class**
  - Teak Burma
  - Shisham
- **Softwood 1st Class**
  - Deodar
- **Softwood 2nd Class**
  - Kail
  - Chir
  - Partal
  - Spruce
  - Garjan
  - Loagerstoemia

Wood types to be used shall be taken as per architectural details.

### 2. General Characteristics

All the timber shall be in accordance with the requirements of BSI No: 1186, ‗Quality and Workmanship in Joinery'.

The whole of the timber shall be from the heart of sound and fully grown tree, uniform in substance, straight in fibber, first class quality properly seasoned, free from large or loose dead knots, and open shakes and excessive sapwood. The scantlings of all timbers shall be bright, sound and square edged. The moisture content of timber shall not be more than ten (10) percent.

### 3. Preservation of Wood

Prior to installation of all finish wood works in their respective positions, preservatives shall be applied to safeguard the woodwork against fungus, termite and bores.

The preservatives shall be of the best available quality of solignam oil (clear) as approvedby the Engineer. The method of application shall be strictly in accordance with the manufacturer's instructions. The treatment and application of all the preservatives shall comply with the requirements of BS-CP 98:1964.

4. **Adhesive:**

The adhesives shall conform to the requirements of BSI No. 745 "Animal Glues for Wood" or as directed and approved by the Engineer.

5. **Nails and Screws:**

All Nails shall comply with BS 1202, screws with BS 1210, bolts with BS 916 and timber connectors with BS 1579.

6. **Ply Wood**

a. The plywood shall comply in all respects with BSI No. 1455:1963. All the plywood shall only be obtained from manufacturers approved by the Engineer.

b. Plywood used for doors, paneling and other similar works shall be to the thickness and size as shown on the Drawings or as directed by the Engineer. The grade shall be first quality and the face and back shall be free from end joints, dead knots, overlaps, patches and other surfaces shall be free, smooth for painting or polishing.

c. The veneer shall be of the required thickness and quality including base veneer and shall be impregnated with an approved adhesive and machine compressed. Such machine pressed veneered wood shall be fixed on all sides of the inner core wood (softwood of approved quality) after it has been treated with water resistant hot setting glue.

d. External quality plywood shall have Grade 2 veneer with WBP bonding and internal quality plywood shall have Grade 2 veneer with MR bonding.

7. **Manufactured Boards**

a. Blockboard shall comply with BS 3444 Grade 2.

b. Chipboard shall be resin-bonded wood chipboard complying with BS 2604.

c. MDF boards shall be ―Lasani Board‖ complying with BS 1142 -89.

d. Gypsum plaster board shall comply with BS 1230.

8. **Decorative Plastic Laminate**

Decorative laminated plastic sheeting shall be 0.6 mm thick locally available complying to BS 3794 Class. Color and type shall be to the approval of the Engineer.

9. **Priming Coat**

Priming Coat shall comply with BS 2521.

10. **Wood Treatment**

Prior to fixing in position, all the timber including ceiling frames, joints, purlins, planks, all the door frames, furring strips, blocking, grounds, nailing strips scantlings, boards etc. in contact with concrete or masonry or wood or other materials shall first be treated with clear Termidor insecticide for termite proofing with approved pressure spraying equipment. All spraying will be done within one week of working of the material. Spraying shall once again be done at the site, after delivery and before installation in accordance with manufacturer's instructions and complying with BS 1282.

**11. Ground, Blocking and Nailing Strips**

Ground, blocking and nailing strips shall be provided in ceiling and elsewhere as necessary or as shown on Drawings to receive the Work included herein ad as required for the Work of other trades.

Except as otherwise shown or specified and approved by the Engineer, ground, blocking and nailing strips shall be secured in place as follows:-

- To steel – by means of ½‖ diameter bolts spaced not over 4 ft.
- To concrete blocks - by the use of steel cut nails spaced not more than 4 ft. apartand driven directly into the block.
- To poured concrete – by means of galvanized screws as per details shown on the Drawings.

**12. Glues**

All glues and adhesives used in carpentry, joinery and in the door manufacture shall be synthetic resin adhesives to BS 1204, unaffected by oil, gasoline and solvents, resistant to the growth of fungus and bacteria, immune from insects and such that the cured glue shall not be harmed by paint and lacquer solvents. The Contractor shall furnish a guarantee that the adhesives/glues used in the manufacture of all doors, joinery and paneling work conform to the Specifications stated above. All the samples of gluing materials shall be subject to the approval of the Engineer before use.

## 10.04 SAMPLES

All samples of the material used for the work under this Section of Specification shall be approved by the Engineer and same type of material shall be used throughout the work. If the Engineer desires to get the material tested, this will be done by the Contractor at his own cost from a laboratory approved by the Engineer.

## 10.05 FABRICATIONS

**General**

Unwrought' timber shall be used. Sawing shall be done true to the size and dimensions to finally meet the requirements of specified sizes and dimensions of the finished work.

All framing shall be joined as shown on the Drawings or as directed by the Engineer. Alljoints shall be secured with sufficient number of nails. The Contractor shall perform all necessary mortising, tenoning, grooving, matching, tonguing, housing, rebating and all operations required for the correct jointing. The Contractor shall also provide all metal plates, screws, nails and other fixing material that may be ordered by the Engineer for the proper execution of the joinery work. Fabrication that develop defects due to bad workmanship or unsound materials not conforming to these specifications and the directions of the Engineer, shall be cut out and replaced at Contractor's own expense before the expiry of the maintenance period.

**Doors**

Verify design and size of doors required for each opening. Door thickness shall be 40 mm (1 1/2 inch.) unless otherwise indicated.

Fabricate flush wood doors in accordance with the following requirements.

**Cores**

Edging of doors, cores and shutters shall be of wood as shown on the drawings planed to a smooth uniform thickness.

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All doors and shutters shall have wood lapping on all edges as per details shown on the drawing.

**Face Panels**

- Door facing on each side of door shall consist of plywood have total minimum thickness of 1/8 inch before sanding.

- Door plywood shall be bonded to each other, and to core unit with approved adhesive and machine compressed.

## 10.06 PROTECTION OF MATERIALS

All materials and assembled units shall be protected from weather and stored in such a way as to prevent decay and attack by fungus and termites.

## 10.07 WOODEN DOORS & DOOR FRAMES

### 10.07.1 Materials

- First class Deodar wood as approved by the Engineer shall be used for the doorframes and full/half glazed and paneled shutters.

- The plywood and veneering shall be of selected best quality as approved by the Engineer.

### 10.07.2 Exterior and Interior Door Frames

All exterior and interior door frames shall be constructed 18 SWG MS sheet or of wood as shown on the drawings.

The door frames shall be secured in place by means of mild steel anchors welded/screwed in place and built into the masonry as it is being constructed. Thereshall be one such anchor near the top and bottom of each jamb but not over 900mm intervals between the top and bottom anchors.

### 10.07.3 Exterior and Interior Wooden Doors

The Engineer shall unless otherwise shown or specified, of the paneled type, flush and type as shown on the Drawings or as direct the exterior and interior wooden door.

**All the door shall conform to the following requirements:**

Paneled doors shall be constructed in accordance with the requirements of Part I of British Standard Specification No. 459 with the additional requirements that panels in exterior openings shall be assembled with waterproof glue, glued tacked in place. Flush door shall comply with BSI 459 Part-2 and shall consist of solid core 40mm(1 1/2 inch.) thick shutters as shown on drawings.

### 10.07.4 Door Shutters

The shutters will be fixed to the frames with approved quality hardware schedule.

All doors, shutters shall be fabricated in a workman- manner strictly to the correct sizes and shapes as shown on the Drawings or as directed by the Engineer.

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The door shutters shall have solid core as shown on the Drawings. It shall be built in sections, properly jointed and glued together, both sides being covered with plywood of the required thickness and approved quality. The surfaces shall be prepared for painting or polishing.

The arrangements of inner core for solid shutters shall be approved by the Engineer. It shall be so adjusted that circulation of air is free and uninterrupted. Minute holes shall be provided in edges at suitable places to admit and exit air.

Each door shall be constructed so as to permit the installation of hinges, knobs andnlocks in the position shown on the Drawings.

Completed doors shall be sound, rigid and free from defects and warp. All edges shall have Deodar wood lipping and shall be aligned and smooth, joints shall be close fitting, hard wood doweled or mortised framed and of strength to maintain frame and of strength to maintain the structural properties of the member connected. All adjoining edges and faces shall be flush and smooth. Edges shall be rectangularand solid.

### 10.07.5 Fitting. Hanging and trimming

All the doors shall be fitted, hung and trimmed as hereinafter specified and as indicated on the Drawings.

Doors shall have a clearance of 4 mm at sides and top unless otherwise directed by the Engineer and shall have 5 mm clearance at bottom. Doors shall be hung and trimmed with hardware as specified. All the locks shall be installed at the same height and shall be located at height as directed by the Engineer.

### 10.07.6 Hardware

Hardware shall be of approved quality and first class finished material. The Contractor shall obtain prior approval from the Engineer for quality; shape and pattern of all the hardware materials by providing samples and shall provide and fix only the approved hardware materials.

Hardware shall be carefully and securely fitted. Upon handing over the work, hardware shall be demonstrated to operate freely. Keys shall be placed into respective locks and upon acceptance of the work keys shall be tagged anddelivered to the Employer.

### 10.07.7 Quality Assurance

**Tolerances: Doors shall be fabricated to the following**

- Size: Plus or minus 1.6 mm overall dimensions
- Maximum Wrap: 3mm
- Squareness: Maximum diagonal difference 3mm (between length of diagonal measured on face of door from upper right corner to lower left corner and length of diagonal measured from upper left corner to lower right corner).

### 10.07.8 Submittals

a. Provide shop drawings showing door types, details and locations, referred to the door type and hardware group shown on door and hardware schedules.

b. Provide certificates stating that doors were constructed timbers of the species specified having moisture content and meeting equilibrium and relative humidity requirements.

c. Submit samples of face veneers for selection of color and pattern.

10.07.9 Product Delivery, Storage and Handling

a. Keep products dry, stack products off ground on level platforms, fully protected from weather, including direct sunlight.

b. Identify type, size and location of each door in order to permit installation at correct location.

10.07.10 Installation

a. Install doors at correct openings and assure smooth swing and proper closerwith frames.

b. Install finishes hardware in accordance with manufacturer directions.

## 10.08 KITCHEN CABINETS/WOODEN

### CABINETS/WARDROBES/DRESSERS/SHELVES/SEATS

All kitchen cabinet/ wardrobes/ dressers/ shelves/ seat/ file cabinets including fittings, fixtures and hardware's shall be supplied of approved manufacturer and shall be of best quality fabricated by using materials and details as shown on the drawings.

10.09.01 Installation

All cabinets, wardrobes and shelves/seat shall be installed in position by the skilled workmen specialized in the job. Works shall be executed in accordance with drawings and the Engineer's instructions.

The Contractor shall inspect delivered cabinets, wardrobes seats and shelves and related parts for indication or location, size required by field measurements, finishing hardware and similar preliminary works. Verify locations for installation, required floor and wall finishes, painting and all other related work. Cabinets/wardrobe, shelves and seats shall exactly flush the floor and wall surfaces. Cut and fit accurately scribe strips at wall surfaces and bases. Secure wall cabinet to blocking. Concealed fasteners all joints surfaces shall be smooth and even. Doors and other moving parts shall exactly fit in the frame. Refit, as necessary, to ensure proper and easy operation. Refit, if necessary, all cabinet, wardrobes and shelves hardware, test for proper operation, remove for painting and other finishing and properly replace in position with all fittings and accessories.

All work shall be thoroughly protected from damage at all times by suitable methods approved by the Engineer. Adjacent works shall similarly be protected from damage. Any damage or disfigurement shall immediately make good at Contractor's expense.

10.09.02 Cabinet work will be coordinated with Employer supplied items (if any) such as cooking range etc.

10.09.03 Kitchen cabinet work, generally al! Framing will be in treated Deodar wood with portions' etc., in best quality commercial plywood. All exposed surfaces will be covered by approved laminates. Exposed edges, if any, will be covered by polished Deodar wood lipping. Where approved counter tops for kitchen will be specified thick selected marble on painted M.S. framing.

10.09.04 Best quality hinges, metallic drawer guides (with bearing) and handles will be used. Samples and shop drawings to be approved by Engineer.

10.09.05 **Wardrobes**

Wardrobes (and similar works) will be made of deodar wood. Internal partitions will be as shown on the drawings. Shutters will have a (deodar wood) louvered front backed by laminated plywood. All louvers and exposed deodar wood edges/faces will be polished. Best quality hinges metallic drawer guiders (with bearing) handleslocks catches etc., will be used. Shoe rack (inside wardrobe) will consist of 13mm dia (hollow) chrome plated M.S. rods. Samples and shop draw to be approved by the Engineer.

## 10.09 FIRE RESISTANT RECORD CABINET CONSTRUCTION OF FIRE RESISTANT RECORD CABINET

**Design:** The cabinet shall be designed to protect the contents (paper media documents) against fire as well fall & impact during fire. The Fire protection shall be for minimum 2 Hr ratingas per ASTM D-1360-98. The external shell of the cabinet shall be 2 mm thick and internal shell 1.6 mm thick, further fortified by suitable fire resistant barriers to meet the required protection. The overall protection to the contents shall be minimum 70 mm on all six sides.

**Door:** The external door of the cabinet shall be minimum 2 mm thick as per ASTM D-1360-98, further fortified with hard plate for min burglary protection and fire resistant barrier material to meet required fire protection.

**Bolt work:** The door shall be secured by four way locking mechanism / Bolt work with minimum 8 moving shooting bolts of minimum 20 mm diameter, shall be provided.

**Locking:** Minimum eight lever dual control key locks, made up of Brass (body and levers), as per ASTM D-1360-98, shall be provided.

**Corrosion resistance process:** All steel parts of the safe shall be processed for corrosion resistance, by seven-tank treatment and further primed with epoxy primer. The finishing layer shall be of best quality Nitro Cellulose paint.

**Capacity and storage system:** The storage capacity shall be minimum 640 Liters with minimum usable internal sizes as 1620 (h) x 670 (w) x 590 (d). The cabinet shall be provided with minimum four nos. adjustable shelves.

**Testing:** The FRRC should be tested at CBRI as per ASTM D-1360-98 for Fire Endurance Testfor 120 minutes. Certification for the same must be provided.

**Qualifying Criteria:** The tenderers should fulfill the following qualifying criteria. They shall submit copies of documents to substantiate their qualifications along with the technical and commercial bids failing which their tenders are liable to be rejected.

- Only manufacturers are eligible to submit tenders.
- The Tenderer should have a Registered Office and Distribution set up and should havebeen dealing with manufacture and supply of FRRCs for the last ten years.
- The Tenderer should have well established and efficient service network at all majorcities or near the places where the safes are to be supplied.
- The Tenderer should furnish audited financial statements for the last 3 years giving segment wise turnover details of Safes.
- The Tenderer shall furnish copies of IT assessment orders for the last 3 years.
- The Tenderer shall furnish ST / VAT Registration numbers.
- The Tenderer should be an original equipment manufacturer of locks. The lock making process should be computerized.
- The Tenderer should be a total security solutions provider, with capability of offering Banking Security products such as Safes, Strong Room Doors and Safe Deposit Locker cabinets.

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## 10.10 WOODEN LOUVERS

If shown on Drawings, wooden louvers shall be made in first quality seasoned deodar wood. Frame with recesses on sides to receive louvres shall be made as per details shown on the Drawings from first quality seasoned deodar wood planks and louvers shall be securely fixed in the recesses. The frame shall be anchored by means of 1‖x4‖ M.S. hold fasts, and shall be perfectly in line and plumb.

## 10.11 ARCHITRAVES, MOULDINGS AND TRIMS

Architraves, Mouldings, Beadings, miscellaneous trim and scribe pieces shall be provided as shown on Drawings and shall be in deodar wood shop milled to type, profiles and machine sanded to a smooth and even finish all to the approval of Engineer. On running trim, all outsidescorners to be mitered and shall be leveled. All flat trim is to be blocked out to prevent warp. Nailing is to be concealed wherever practicable and all nails are to be driven below surface, filled in and polished or painted as specified

## 10.12 DEFECTIVE WORK

In the event of non-conformance to specification and drawings, the wood works shall be rejected by the Engineer and the Contractor shall remove and replace the rejected work by new work of same specifications.

## 10.13 SURFACE PREPARATION

The surfaces of all wood works shall be prepared in the manner as directed by the Engineer for polishing and painting.

## 10.14 MOCK-UP SAMPLE

After approval of shop drawings and tests etc., the contractor shall submit at his own cost one mock-up sample of each type of wood works complete with all fittings/fixtures accessories priorto the actual fabrication of the bulk.
The samples shall be returned to the Contractor for incorporation in the works after installationof at least 80% of the works.

## 10.15 MEASUREMENT AND PAYMENT

Door shutters shall be measured per square Meter/ feet rough opening area, complete and approved, including cost of door frames, hardware as specified in Drawings, architraves/beadings etc. supply, fabrication, fixing, installation, at the unit rates entered in theBill of Quantities.

No separate payment shall be made for Termite Proofing for carpentry/joinery items and shall be deemed to be included in the rates of relevant items.

All other items shall be paid at the rates entered in the Bill of Quantities.

*** END OF SECTION***

# SECTION - 11
# ALUMINUM WORKS

## 11.01 SCOPE OF WORK

The work under this section of specification includes furnishing all labor, equipment, appliances and materials and performing all operations in carrying out the work of anodized aluminum doors, windows and ventilators (other than curtain wall type doors and windows) ventilators, louver and fly screen. All related items such as sealants, rubber gasket for glazing, netting, rollers, latches, fastenings, glazing, anchor bolts and all items supplied by other trades and customarily built in and/or installed in strict accordance with this section of the specifications and as shown on the applicable drawings and subject to the terms and conditions of the Contract.

## 11.02 APPLICABLE STANDARDS

Latest editions of following ISO and British Standards are relevant to these Specifications wherever applicable.

### a. ISO (International Organization for Standardization

| | |
|---|---|
| 1804 Doors | - Terminology |
| 6442 Door Leaves | - Measurement of defects of general flatness, |
| 6443 Door Leaves | - Measurement of dimensions and defects of squareness. |
| 6444 Door Leaves | - Test of behavior under humidity variations (successive uniform climates) |
| 6612 Windows& Doors | Wind resistance tests |
| 6613 Windows& Door | - Air permeability test. |

### b. BSI (British Standard Institution)

| | |
|---|---|
| 1227 | - Hinges |
| 4873 | - Aluminum alloy windows |

## 11.03 GENERAL

a. Aluminum doors and windows shall be of profile, pattern and design shown on drawings and manufactured by reputable manufacturer approved by the Engineer. The contractor shall provide manufacture literature completely describing the product, instructions for installation and maintenance.

b. All the sections used for doors, windows, ventilators& fly screens shall be of best quality aluminum products such as equal and unequal angles, channels, tubes, corrugated strips, moldings etc., in accordance with International standards conforming to ASTM B308 & B221.

c. All doors windows& ventilators shall be of type and size indicated on drawings and shall conform to the requirements shown and specified herein.

d. Contractor shall arrange tests and analysis if directed by the Engineer of scaled models of each window type at the maker's works or any laboratory specified by the Engineer for the material supplied by him to be tested in the presence of the Engineer's Inspector, to whom test certificates, proof sheets, etc. shall be furnished. The models shall be submitted to the Engineer for approval prior to testing. Nevertheless, neither the fact that the materials have been tested in the presence of the inspector nor that the Engineer mayhave been furnished with test certificates in lieu of sending an inspector to the works shall affect the liberty of the Engineer to reject, after delivery of materials found not in accordance with these specifications.

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e. The contractor shall submit shop drawings, which shall show full construction details, quantities and locations, fastenings and attachment to adjacent construction and materials. Shop drawings shall be submitted at the proper time to allow for checking, revisions, and agreement and to permit manufacturer's product delivery and start of site work to suit the building program. The Contractor shall submit representative samples of finished windows, anchoring mechanism, embedded parts, fastenings, glass panes, accessories and other materials for the Engineer's approval.

f. After approval of shop drawings and tests etc., the contractor shall submit at his own costone mock-up sample of each type of aluminum works complete with glazing, all component assembly method and required fittings and accessories prior to the actual fabrication of the bulk. The samples shall be returned to the Contractor for incorporation in the works after installation of at least 80% of the works.

g. Fabricate and assemble all work in the shop of the approved manufacturer to reduce field fabrication to a minimum unless otherwise directed by the Engineer.

h. The glass shall conform to specification laid down under section 'Glazing' and shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to size as shown on drawings, so as to fit the grooves in door and window members. All the glass shall be best quality of approved manufacture.

i. The structural shape of the Aluminum members shall be of uniform quality, color and temper, clean, round, commercially straight and free from injurious defects.

j. All doors, windows and ventilators shall be fabricated as a complete unit, fully airtight and watertight, including rubber gasket for glazing, rollers, latch, anodized in specified color, inclusive of glass sheet, necessary holes for fixing, door locks, door closures and window locking requirements, all as approved by the Engineer.

k. Contractor shall, on request, get certificate signed by the manufacturer stating that each lot has been sampled, tested and inspected and has met the requirements in accordance with these specifications, and the same shall be furnished to the Engineer.

## 11.04 MATERIAL

### 11.04.1 Aluminum

a. All aluminum extruded sections shall comply with BS 1470 to BS 1474 and shall be manufactured by Pakistan Cables or approved equivalent. Certificatesof origin shall be supplied in all cases.

b. All aluminum shall be anodized to comply with BS 3987 and 1615 with an anodic film thickness of not less than 25 microns. All surfaces are to be anodized.

c. Aluminum shall be supplied in natural matt anodized finish to the approval of the Engineer.

d. The Contractor/manufacturer shall provide 25 years guarantee of 25 micron anodized aluminum extruded sections against corrosion to the satisfaction of the Employer.

### 11.04.2 Other Components

a. All glazing gaskets are to be vinyl glazing channel gaskets (extruded Neopreneor Hypalon). Gaskets shall conform to commercial standard CS-230-60.

b. All draught seals are to be either in Neoprene as above, or in approved nylonpile, of density and configuration suitable for the designed condition.

c. All fly screens are to be approved pattern aluminum screens.

d. Hardware shall be manufacturer's standard match door and windows finish.

e. Joint sealant shall be approved elastomer.

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f. The finish shall be in approved color in accordance with the standards of Aluminum Association.

g. Minimum coating should not be less than 23-25 micron.

11.04.3 Fixings

All fixings shall be in aluminum, non-ferrous metal or stainless steel, selected to prevent galvanic action with the components fastened. In no circumstances shall untreated or painted steel fixings be employed on any part of any door or window component.

11.04.4 Glass and Glazing

Glazing shall be provided as shown in Drawings and Bill of Quantities and shall meet the Specification requirements as described in ¯Section 12 – Glass & Glazing‖.

11.04.5 Frames/Shutters

The frames/shutters of anodized aluminum doors, windows, ventilator and louvers shall be formed from rolled, strip or extruded aluminum and be as per drawing. Fastening bolts and screws shall be made from hardened aluminum.

## 11.05 WORKMANSHIP DESIGN AND FABRICATION

The Contractor shall be responsible for the protection and installation of all items furnished. Allitems shall be installed plumb and square and shall be solidly anchored in a good workman likemanner in accordance with the manufacturer's instruction and as specified herein. The Contractor shall be responsible for the protection of installed items from damage by other trades. All items shall be left in operating, neat and clean condition, free from dirt, finger marks, etc. The Contractor shall be responsible for final cleaning before the final acceptance.

The glass panes shall firmly be secured in the rebates with the rubber gasket. Ensure that the beads and grooves are clean, dry and unobstructed at the time of glazing. The complete unit shall be airtight and watertight on completion. No doors windows ventilator louvers shall be considered complete until and unless the fingerprints and other stains and marks have been removed from the surface of glass and aluminum.

## 11.06 PRODUCT DELIVERY AND STORAGE

11.06.01 Deliver doors, windows, ventilator and louvers in a manner preventing damage to units. Store materials off the ground under cover in a manner preventing deterioration or damage.

11.06.02 All embedded parts and anchor bolts shall be delivered to the site carefully and keeping the fabricated shape and configuration. All these parts shall be suitably marked for identification.

## 11.07 FIXING AND ERECTION

11.07.01 All aluminum doors, windows & ventilators shall be fixed in strict accordance with the manufacturer‘s detailed requirements and recommendations, using only fixing components specified by them, by operative experience in this work. All windows & ventilators shall be solidly and rigidly fixed, square, level, plumb and without distortion; all opening lights and hardware are to be eased, oiled and otherwise left operating smoothly.

11.07.02 All aluminum protection is to be left in place until all surrounding wet trades have been completed and cured; then removed by approved means.

11.07.03 Raw plugs and anchoring bolts shall be embedded into the concrete or block masonry for holding the doors, windows, ventilators and louvers in their correct positions.

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11.07.04 Care shall be taken to install the doors and windows, ventilators and louvers in line and plumb& solidly anchored in a good workman like manner in accordance with the drawings. Should any scale or scratch appears on the surface of doors, windows, ventilators the contractor shall at his own expense and louvers the contractor shall at his own expenses and at the Engineers direction have all exposed surfaces cleaned to bare bright specified color.

11.07.05 All works shall be installed in strict accordance with the manufacturer's instructions.

## 11.08 PROTECTION AND CLEANING

11.08.01 Temporary protection shall be achieved by applying water-soluble protective coating capable of withstanding the action of lime mortar.

11.08.02 Apply coating in the manufacturer's plant to the exposed surfaces of all components.

11.08.03 Before application of coating, remove all fabrication compounds, moisture and dirt accumulations.

11.08.04 All the aluminum doors, windows & ventilators and other items shall be protected throughout the Contract period.

11.08.05 Any damage occurring to any of the member of the windows & ventilators before the Contract completion from whatever cause shall be rectified or replaced at Contractor's cost, all to the satisfaction of the Engineer.

## 11.09 DEFECTIVE WORK

In the event of non-conformance to specifications and drawings the aluminum work shall be rejected by the Engineer and the Contractor shall remove and replace the rejected works by new work of same specifications.

## 11.10 GUARANTEE

The manufacturer shall furnish his standard written guarantee against leakage of rain, excessive infiltration of dust and air and all defects in materials and workmanship covering all work under this section.

Such guarantee shall be in addition to and not in lieu of all other liabilities, which manufacturersand the Contractor may have by law or by other provisions of the Contract Documents.

## 11.11 MEASUREMENT AND PAYMENT

Aluminum doors, windows & ventilators shall be measured per Square Meter/feet and paid forat the unit rates entered in the Bill of Quantities and as per the terms and Conditions of this Contract.

The unit rates shall include the cost of all glazing, aluminum sections, hardware, fly screens, fixing accessories, gaskets, sealants etc., fixing and installation, complete in all respect.

*** END OF SECTION***

# SECTION - 12
# GLAZING

## 12.01 SCOPE OF WORK

The work under this section of the Specifications consists of furnishing all labor, equipment, tools, appliances, scaffoldings and providing glass gaskets, sealants, compound and other materials required for performing all operations in connection with the installation and setting of all types of glass, glazing and glass blocks complete in every respect in accordance with the Drawings or as directed by the Engineer. The scope of this section of Specifications is covered with detailed Specifications as laid down herein.

## 12.02 APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications wherever applicable.

**BSI (British Standards Institution)**

952 Glass for glazing

5051 Security glazing Part I&I)

CP.152 Glazing

## 12.03 GENERAL

a. Glazing sealant shall be as recommended by the manufacturer for the particular application.

b. Spacer shims (distance pieces) shall be elasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on drawings between glass and rebates, bead or cleat. Depth shall give not less than inch cover of glazing sealant.

c. Contractor shall submit samples for each type of glass, minimum 4 ft. x 4 ft. in size with protective edges. Samples of glazing sealant minimum 0.1 liter of specified types shall be submitted. Samples of minimum of three glass blocks shall also be submitted.

d. Contractor shall submit 1 feet long sample of each type of glazing gasket.

e. Contractor shall also submit printed materials manufacturer's installation instructions for specified glazing gaskets, compounds sealants and accessories including description of required equipment and procedures and precautions to be observed.

## 12.04 DELIVERY STORAGE AND HANDLING

a. Contractor shall deliver materials in manufacturer's original, unopened containers clearly labeled with manufacturer's name and address, material, brand, type, class and rating as applicable.

b. Contractor shall store the materials in original unopened containers with labels intact/protected from ground contact and from elements which may damage glass.

c. Contractor shall handle the materials in a manner to prevent breakage of glass and damage to surfaces.

## 12.05 MATERIALS

### 12.05.1 General

Glass shall be free from all blemishes, bubbles, distortions and other flaws of anykind and shall be properly cut to fit the rebates so as to have a uniform clearance

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of 1.6 mm round the panes between the edges of glass and the rebates. All glass shall be best quality from reputable manufacturer (USA/Sweden) as approved by the Engineer.

### 12.05.2 Glass

Glass for windows, and ventilators and louvers shall be of specified thickness and of approved quality.

**Clear and Tinted Plate Glass**

Clear plate glass shall be imported glass complying with BS 952 Part I M Table 2, Ordinary Glazing Quality.

The single glazing shall comprise of 5 mm thick clear/ tinted plate glass.

The double glazing shall comprise of an assembly of two glass panels of clear plate glass each 6 mm thick, with a 12 mm separator between them and hermetically sealed

**Clear Laminated Glass**

Clear Laminated glass shall comply with BS 952, ASTM C1036 or C1048. The thickness shall be 11 mm.

**Glass Bricks**

Glass bricks/ blocks shall be best quality imported glass bricks/ blocks, to the approval of the Engineer and shall comply with BS 1207.

### 12.05.3 Glazing Sealants and Compounds

Contractor shall provide material colored to match frame in which glass is installed. Provide only compounds known to be fully compatible with surfaces, which they will contact as follows:

- Two component polysulfide glazing sealant.
- One component acrylic glazing
- Acrylic-latex glazing sealant consisting of modified latex rubber and acrylic emulsion, non-hardening, non- staining and non-bleeding.
- Cleaners, Primers and sealer as recommended by the sealant manufacturer.

### 12.05.4 Accessories

All sealants, neoprene gaskets, tapes, cords, bedding materials, etc. shall be those recommended by the manufacturer for application to aluminum or other window frame materials to suit the environmental conditions.

**Glazing Sealant**

It shall be tape or ribbon of polymerized butyl or mixture of buty 1 and polyisolbutylene compounded with inert fillers and pigments, solvent based, 95 percent solids thread or fabric reinforced, paintable, non- staining.

**Setting Blocks**

It shall be chloroprene (Neoprene) 70 to 90 durometer hardness, compatible with sealant used, channel shaped and of the necessary height for proper perimeter clearance.

**Channels, Gaskets, and spacer's**

It shall be chloroprene (Neoprene), 40 to 50 durometer hardness compatible with sealant used.

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## 12.06 INSTALLATION OF GLAZING

a. Glass is to be handled with care, and placed into openings without distortion, set on such spacers, sprigs or other components as recommended.

b. Glazing shall comply with the recommendations of glass and glazing materials manufacturers.

c. Examine each piece of glass and discard and replace glass with edge damage or face imperfection. All glazing shall be wind tight and fully water tight on completion.

d. All rebates, grooves, etc. for glazing shall be prepared by thoroughly cleaning of all dirt, dust, oil, grease and other foreign matter. Clean glazing channels and other framing members indicated to receive glass. Remove coatings, which are not firmly bonded to thesubstrate.

e. Remove lacquer from metal surfaces wherever elastomeric sealants are to be used. Apply primer and sealer to joint surfaces wherever recommended by the sealant manufacturer and as shown on the drawings.

f. All glass shall be cut to suit each opening, perfectly square, and with due allowance for glazing tolerances, thermal expansion as recommended by the manufacturer.

g. Trim and clean excess glazing materials from surrounding surfaces immediately after installation and eliminate stains and discolorations.

h. Cure glazing sealants and compounds in compliance with manufacturer's instructions toobtain high early bond strength internal cohesive strength and surface durability.

i. All glazing secured by neoprene gaskets is to be held in place by full enclosure of gaskets, applied with approved tools, corners continuously gasketted not mitred.

j. While glazing operation is in progress care shall be taken to avoid breakage or damage to the glass and adjoining glazing. The Contractor shall make good at his own cost, all glass broken by his workmen while cleaning or carrying out other operations. On the completion of the glazing work, all glass that has been set by the Contractor shall, if it becomes loose, within the maintenance period, be refixed at Contractor's expense.

k. No glazing shall be considered complete until and unless paint and other stains have been removed from the surface of the glass ad checked by the Engineer for water tightness.

l. All glazing, by whatever method employed, shall be completely watertight and sound, and generally be in accordance with B.S.C.P. 152 Section 4/404.

m. All glass shall thoroughly be cleaned on completion

## 12.07 PROTECTION AND CLEANING OF GLAZING

Glass shall be protected against damage. Any damaged or broken glass shall be removed and replaced by the Contractor at his own cost to the approval of the Engineer.

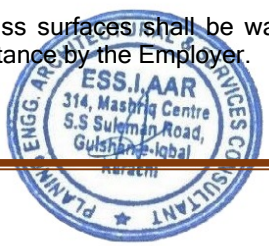
## 12.08 ACCEPTANCE

Labels showing glass manufacturer‘s identity, type of glass, thickness and quality will be required on each piece of glass. Labels must remain on glass until it has been set and inspected.

## 12.09 CLEANING

Remove all smears, labels and excess glazing sealant, leave clean inside and outside free from scratches. The Contractor shall be responsible for the protection of installed glass. Before final acceptance, damaged or broken glass shall be removed and replaced with new glass at no additional expense to the Employer.

All glass surfaces shall be washed clean both inside and outside within two weeks prior to final acceptance by the Employer.



Any labels, smears, stains, marks, spots and dirt etc. shall be removed from the glass and theglass shall be washed clean on both sides taking care not to scratch or damage the glass.

Plaster, mortar, paint, excess sealant, putty etc. or any other material shall be removed immediately after contact with the glass and shall not be permitted to remain on the glass surface.

## 12.10 GUARANTEE

Contractor shall provide a guarantee that all glazing joints in exterior openings shall remain water tight for a period of at least ten years after the acceptance of the building. The Contractor shall also guarantee that during the above period, glazing gaskets & sealants shall not crack, dry out, crumble or fall away from smash on glass.

## 12.11 SAMPLES

Samples of all kinds of materials to be used on the job shall be submitted to the Engineer for approval. Approved samples shall be retained by the Engineer to form standards against which all deliveries will be judged.

## 12.12 TESTING

All materials shall be subject to standard testing and specifications such as ASTM, British Standard or equivalent. If any item found below the specified standard, shall be rejected and removed from the Site immediately and replaced by the Contractor at his own cost.

## 12.13 MEASUREMENT AND PAYMENT

No separate payment shall be made for the supply, installation and fixing of glass/ glazing as per the requirements of this section of Specifications but is deemed to be included in the unit rates of the relevant items of aluminum doors, windows, ventilators, glazed screens/walls etc. entered in the Bill of Quantities.

Glass bricks/ blocks shall, however, be paid separately per square meter/feet for the supply, installation and fixing as per the requirement of this section of Specifications at the unit rates entered in the Bill of Quantities and as per the terms of the Conditions of this Contract.

***** END OF SECTION *****

## SECTION - 13
## ROOF WATER PROOFING

### 13.01 SCOPE OF WORK

The works under this section of the Specifications consists of furnishing all plant, labor, equipment, appliances and materials and in performing all operations in any floor and at any height in connection with installation of insulation, water-proofing and built-up roofing, including water proof treatment to roof, terraces, balconies and other roofing structures complete in strictaccordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the Contract.

### 13.02 SUBMITTAL

13.02.1 Shop Drawings: Shop drawings showing layout and all the details for construction.
13.02.2 Samples of all materials proposed for use under this section shall be submitted to the Engineer for approval.

### 13.03 MATERIALS

a. Bitumen 10/20 grades.
b. Polyethylene buildings film visqueen standard or approved equal. The film shall be 200-500 micron thick, as specified in drawings
c. Cement and aggregates shall be in accordance with specifications Section for "plainand reinforced concrete".
d. Mud mortar composed of stiff clay mixed with an equal bulk of chopped ricehusk/bhoosa.
e. Brick tiles conforming to specifications of relevant section.
f. Heat insulation tiles
g. SBR water proofing chemical, to be mixed with 0.5‖ thick CC slurry, as per manufacturer/ supplier requirements
h. Water proofing membrane of thickness as specified in drawings

### 13.04 DELIVERY STORAGE AND HANDLING

Materials shall be protected from damage during loading shipment delivery and storage non-staining materials shall be used for blocking and packing.

### 13.05 PREPARATORY WORK

All scuppers and roof drains shall be placed and metal flashing, cant strips flanges etc. shall be provided in time to be installed along with the roofing assembly.

All surfaces, to be treated shall be dust free and dry. Application of roof finishes shall not start unless the preparatory work has been inspected and approved by the Engineer.

### 13.06 APPLICATION

a. All water proofing treatment shall be done as specified, as indicated on the drawings,as per manufacturer/ supplier instruction and to the approval of Engineer.
b. Waterproofing shall not be applied during rain or while surfaces are damp, it shall be applied only to surfaces that are clean and dry.

c. Mopping of surface with bitumen shall be performed so that the surface shall be completely covered. Coats of bitumen shall be as specified in drawings. All bitumen shall be applied with mops except that the hot surfacing application shall be poured froma dipper.

d. Polyethylene sheet shall be laid in position wherever shown in drawings. Where joint is necessary at the side or end of the sheet, this shall be a double weld folded joint made by placing the edges together and folding over twice continuously taking the top edge prior to plastering or screeding. The contractor shall protect the sheets from damages during laying and subsequent operation and shall replace at his own cost all damaged sheets to the satisfaction of the Engineer.

e. Mud mortar/concrete screed of specified thickness as indicated on drawing shall be laid in slope.

f. Brick tiles of specified size laid over prepared base to be grouted and flush pointed with cement sand mortar.

## 13.07 MEASUREMENT AND PAYMENT

The waterproofing shall be measured per square meter and paid as per unit rates entered in the Bill of Quantities inclusive of all overlaps, complete in accordance with the terms and Conditions of Contract.

PVC water stop shall be measured per running meter and paid at per unit rates entered in the Bill of Quantities of accepted lengths a complete with accordance with the terms and Conditions of the Contract.

*** END OF SECTION***

# SECTION - 14
# MARBLE AND GRANITE WORK

## 14.01 SCOPE OF WORK

The work under this section of specifications, consists of providing all material, labor, plant, equipment, appliances and performing all operations required for providing and installing marble natural stone slab and tile finishes in floor and special aglow marble stone in floor & skirting, where shown on the drawings, complete in strict accordance with this section of the specification and the applicable Drawings.

## 14.02 SUBMITTALS

Submit three range samples of size as mentioned in BOQ, of each type of marble, granite used; showing color, grade, finishing and texture for approval.

## 14.03 DELIVERY, STORAGE AND HANDLING

Materials shall be protected from damage during loading, shipment, delivery and storage. Non-staining materials for blocking and packing shall be used. Stack marble units at site in accordance with manufacturer's recommendations and as required to prevent staining, scratching, etching or breakage.

## 14.04 MATERIALS

### 14.04.1 General

The marble/granite work of all types should be consistent in type, color range and texture.

Provide slabs or tiles of specified sizes in floor and wall areas as shown on drawings.

Provide marble/stone of specified thickness. Saw-cut the back surfaces that aremeant to be concealed in finished work.

Provide irregular shaped units, staircase units and skirting base units to the profiles of required, with arises sharp true and matched at joints, polish exposed edges.

### 14.04.2 Marble/Granite Type

All marble/granite types are to be selected, as shown in drawings, as written in BOQ and as approved by the Engineer for quality, color and texture as:

a. Marble of local origin or imported, first class quality and high class finish acceptable to the Engineer.

b. As approved by the Engineer.

c. Granite shall be of good quality, 16 ± 2mm thick, having smooth, hard polished surface, regular in shape, size and of uniform thickness, of good appearance, and of sharp and square edges. It shall be free from cracks and other defects.The color and size shall be as per the instruction of the engineer and drawing. Sample of granite stone to be used shall be submitted to the engineer and hisapproval should be taken before the bulk purchase. All the granite stone supplied shall conform to the approved sample in all respect.

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### 14.04.3 Beds and Backings

Where applicable, standard cementitious screed and mortar beds and backings,mixed and proportioned by volume shall be as follows:

Grey ordinary Portland cement: 1 part

Sand: 4 parts 2 parts (for granite)

Water: Clean, fresh and free from deleterious substances.

Mortar mixing shall be done as per specification for mortar mixing of block masonrywork

### 14.04.4 Adhesives Grouts and Sealants

Proprietary adhesives, joint grouts and sealants of approved type as required and recommended by the manufacturer for specific application shall be used. The color of the joint grout and the sealants shall match with the color of stone/marble.

### 14.04.5 Marble, Granite Counter Tops

Marble/ Granite slabs to kitchen counters, toilet counters or others shall be provided to sizes and profiles as indicated on the Drawings. The marble/ granite tops shall be provided in configurations to suit the built-in cabinets as per approved shop drawings in approved shade and color, delivered to Site polished and finished to the approval of the Engineer. Marble/ Granite tops for toilets shall be recessed to provide wash hand basins, where required.

## 14.05 EXECUTION

### 14.05.1 Flooring, Skirting and Stair

Apply cement slurry coat over surfaces of concrete substrate immediately prior to placing setting bed. Limit area of application to avoid premature drying out. Install setting bed of required thickness and set marble/stone units before initial set occurs. Apply a thin layer of cement paste to bottom of each unit. Set, tamp and level units immediately. Set units in required pattern with uniform joint widths.

Joints as soon as possible after initial set. Force grout into Joints, strike flush and tool slightly concave.

Remove mortar and grout from surfaces while still moist and as the work progresses. Do not permit traffic on finished surface during setting and for a minimum of 24 hoursafter final pointing of joints.

### 14.05.2 Dressing

Each marble/granite stone slab shall be machine cut to required size and shape as specified in the drawings. All angles and edges of the marble/granite slabs shall be true and square and free from chippings and the surface shall be true and plane. The thickness of the stone shall be as specified in the drawings. No tolerance shall be allowed for thickness.

The marble/granite slabs shall be mirror polished. All v stones shall be brought pre-polished to the site. The contractor shall prepare samples and obtain approval of the Engineers before proceeding with the work.

The contractor shall ensure that no chisel marks are visible on the surface of the stone before fixing. Stones with chisel marks or broken edges shall be rejected.

### 14.05.3 Laying

The base shall be made rough and watered and given a cement wash and then the mortar shall be laid in 19-20 mm. thick layers as per instruction of Engineer. After laying mortar, it should be leveled with wooden floats. Proper slope for draining wash water shall be provided as per instruction of the Engineer. And over this, marble/granite stone should be laid; the joints should not be more than 1.5 mm. The joints should be painted with approved colored cement slurry.

### 14.05.4 Curing

After about 2 hours of laying, the surface shall be covered with wet bags and kept wetand left undisturbed for 2 days.

### 14.05.5 Repair and Cleaning

Remove and replace marble/stone units, which are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units, which do not match adjoining stonework or are not in line and level as shown on Drawings. Provide new matching units, install and point joints to eliminate evidence of replacement. Repoint defective and unsatisfactory joints to provide neat, uniform appearance.

Clean stonework not less than 6 days after completion of work, using clean water andbristle brushes. Do not use wire brushes, acid or caustic type cleaning agents or other cleaning compounds which may be detrimental to the marble/stone finish or joint grout.

### 14.05.6 Protection

Provide covers, boards, supports and all other necessary materials to protect finishedwork from collapse, deterioration, discoloration or damage during installation and until contract completion.

### 14.05.7 Polishing

The finished surface shall be provided with two applications of approved wax polishor as approved by Engineer.

### 14.05.8 Finish

Finally, when the surface is absolutely dry, the surface shall be rubbed with wax to give a glazing surface, as per instruction of Engineer. Care shall be taken that the floor is not left slippery and that ordinary wax is not used under any circumstances

## 14.06 MEASUREMENT AND PAYMENT

Measurement shall be in square meter of exact length and breadth of the floor. Rate shall include materials, mixing, laying, curing, finishing and labor etc. all complete.

*** END OF SECTION***

## SECTION - 15
## FLOOR AND WALL FINISHES

### 15.01 SCOPE OF WORK

The work under this section of the Specification consists of furnishing all plant, labor, equipment, appliances and materials and performing all operations in connection with the laying of cement concrete floors and floor finishes including bases, skirting and dado, complete in strict accordance with this section of the specifications and the applicable drawings and in accordance with the terms and conditions of the Contract.

### 15.02 APPLICABLE STANDARDS

Latest editions of following Pakistan, ISO, British & ASTM standards are relevant to these specifications wherever applicable.

**Pakistan Standard**

P.S. 232 Ordinary Portland Cement

**ISO (International Organization for Standardization**

R 680 Chemical analysis of cements Main constituents of Portland Cement.
R 681 Chemical analysis of cements Minor constituents of Portland cement.

**ASTM (American Society for Testing and Materials)**

C 482 Bond strength of ceramic tile to Portland cement.
C 648 Breaking strength of ceramic tile.
C 650 Resistance of ceramic tile to chemical substances.
C 798 Color permanency of glazed ceramic tile.
E 84 Surface burning characteristics of building materials

**BSI (British Standards Institutions)**

| | |
|---|---|
| 882 | Pt.2 Course and fine aggregates from natural sources. |
| 1199 | Sands for external renderings, internal plastering with lime and Portland cement and floor screeds. |
| 1201 | Pt.2 Aggregates for granolithic concrete floor finishes. |
| 1281 | Glazed ceramic tiles and tile fittings for internal walls. |
| 5442 | Classification of adhesives for use in Construction pt-1 Adhesives for use. |
| 203 | Tile flooring |
| 204 | In-situ Floor Finishes. |
| 209 | Pt.1 Care and Maintenance of floor surface, wooden flooring. |

### 15.03 GENERAL

#### 15.03.1 Samples and Approval

a. All applied floor finishes materials such as terrazzo tiles, marble imported or local, imported Porcelain Tiles and ceramic tiles etc. to be used in the Works shall receive prior approval of the Engineer.

b. Samples of all the materials to be used shall be submitted to the Engineer for his selection and approval before their use in the Works. The Contractor shall strictlyfollow the instructions of the manufacturers and the floor finishes shall be laid accordingly.

c. Floor finishes shall be laid true to the line and level in approved manner satisfactory to the Engineer.

d. Any work covered under this section of the Specifications not conforming to the requirements of the specified quality and workmanship will not be acceptable and shall be rejected and the Contractor shall be required to remove and replacesuch work at his own cost as per the instructions of the Engineer.

### 15.03.2 Floor Screed Beds

a. All floor finishes of an integral nature such as cement concrete flooring, waterproof flooring shall be laid direct on to structural or site reinforced concrete slabs. In these cases, the slabs must first have been fully cured, then hacked, chipped or otherwise roughened to provide a good adhesion key, then brushed, hosed and cleaned thoroughly of all loose concrete, dirt, dust, grease, oil and other impurities. The surfaces shall then be thoroughly wetted for a period of at least a day before the application of the floor finish, and given a thin brush applied cement slurry grout. The floor finishes of integral nature shall then be laid as described in their respective subsections.

b. All floor finishes of an applied nature such as terrazzo tiling, ceramic/marble tiling, etc. shall be laid on a floor screed as described below at 7.03 or as per theinstructions of the Engineer. The floor screed shall be laid to a thickness calculated to be the overall nominal floor thickness less the actual thickness of the applied finish.

c. Care is to be taken to relate finished floor levels to specified floor levels. The screed is to be completely flat, level and smooth, with no projections, low or highareas, etc., and finished with a wood float. Where required, the screed shall be laid to falls as shown on Drawings or as directed by the Engineer.

## 15.04 CEMENT SAND SCREED

### 15.04.1 Preparation of Base

a. The laitance on the base shall be entirely removed by complete chipping, hacking & exposing the clean coarse aggregate. All loose concrete and dirt should be removed by thorough washing or hosing. The Contractor shall not undertake any finishing work until the surfaces are approved by the Engineer.

b. The base concrete shall be wetted thoroughly for a period of at least a day before the application of floor finishes and any excess water is brushed off before laying the screed.

c. Just before the screed is to be laid, a neat grout should be brushed into the base.The grout should consist of water and cement mixed to the consistency of a thickfluid. An approved bonding agent may be used as an alternative to the grout. Excess of the grout shall be removed by thorough sweeping just prior to placing the topping material.

### 15.04.2 Laying of Screed

a. Cement sand screed up to a thickness of 40 mm shall be mixed in the proportions of 1:3 by volume with fine aggregate of approved size and gradation. Screeds over 40 mm thick should be mixed in the proportions of 1: 1 ½ :3 (cement: sand:aggregate) to the approval of the Engineer.

b. Where specified, Aquaguard or an equal approved waterproofing additive shall be mixed in the waterproof cement sand screed in the ratio as per manufacturer's instructions or as directed by the Engineer and shall be finished with a steel float.

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c. Where screeds are to receive terrazzo or marble tiles etc. the screeds shall be finished with a slight rough finish to accept the cement paste and tiles. The mortar bed shall be spread and tamped to an even thickness over an area no greater than that, which can be tiled before the mortar reaches its initial set. However, ceramic tiles shall be bedded over a hard set cement sand floor screed laid earlier and well cured.

## 15.05 TERRAZZO TILES

### 15.05.1 Description

a. Terrazzo Tiles shall generally comply with the requirements of BS 4131 and shallbe as approved by the Engineer.

b. Terrazzo tiling shall be locally manufactured, from an approved manufacturer, specialist in terrazzo tile making. Tiles shall be cast with a cement/sand base, and a pigmented terrazzo topping, cast integral, all in heavy metal moulds underpressure, all to the required sizes and thickness shown on Drawings and to Engineer‘s detailed approval.

c. Tiles shall be selected by the Engineer from colours and patterns as prepared by the approved manufacturer from samples, the cost of which shall be deemed to be included in the rates. The approved samples shall be retained by the Engineer to form standards against which all deliveries will be judged.

### 15.05.2 Materials

a. Portland cement conforming to BS 12.

b. White Cement conforming to relevant BS Specification.

c. Sand and aggregates shall comply with requirements of ASTM C-33.

d. Water shall be clean potable drinking water, free from oils, acids, alkalis, salts, and organic or other injurious matter.

e. Marble chips of approved shade, color, size and quality and shall have an abrasive hardness of not less than 16.

f. Marble powder shall be clean and should be of approved quality.

g. Pigments to be used shall comply with BS 1014.

### 15.05.3 Tile Mixes

a. Tile mixes shall be as under:

- Backing shall consist of Portland cement and fine sand in proportions of 1:5; mixed with a minimum of clean potable water.
- Terrazzo topping shall consist of white Portland cement and granulated marble chips of approved sizes, shade, colour and quality, mixed in proportions dependent on the exact terrazzo selected but average 1:2.

b. The backings shall be placed first into the moulds, then the toppings to a minimum depth of 10 mm; the tiles cast under pressure and filled, ground and polished before delivery to Site. Bottom faces of tiles shall be cast with an approved incised key pattern.

c. All the terrazzo tiles shall be cast to the sizes shown on the Drawings or as approved by the Engineer, perfectly square, with sharp square edges, and consistent in color and texture throughout the Contract for the color/ pattern selected and approved.

d. Curing shall be effected by continuous wetting for a minimum period of 3 days.

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### 15.05.4 Bedding and Finishing

a. Terrazzo Tiles shall be bedded on the wet screeding described above at 7.02.2(b) and 7.03 by applying a thin layer of neat cement paste on to the screed bed and the tiles placed in position and tamped down gently with a wooden mallet to be level with other tiles. The tiles shall be laid in the manner so that they align perfectly to the specified lines and levels and are square. The tiles joints shall be as thin as possible but not more than 2 mm wide and shall be regular and perfectly straight, and setting out shall be carried to ensure a minimum of cut tiles. Any tiles requiring to be cut shall be saw-cut by approved tools. Tiles pattern shall be square to the spaces floored, and any patterning by tile jointing, alternating colors, etc. is to be carried out as indicated on the Drawings and as approved by the Engineer.

b. The surface during laying shall be frequently checked with a straight edge at least 2m long to obtain a true surface with dead level or slope, as directed.

c. All tile joints shall be grouted up solidly with a grout comprising of white Portland cement and water; all surplus to be cleaned off immediately.

d. Once bedded, curing shall be carried out by covering in hessian and continuous wetting for a minimum period of 3 days and the floor kept clear of traffic for at least 48 hours.

e. When cured, the terrazzo tiling shall be machine polished to the approval of the Engineer. Polishing must be evenly and carefully carried out and a perfect smooth surface produced.

## 15.06 MARBLE FLOOR TILES

### 15.06.1 Description

a. The Work included under this subsection shall comprise of providing and fixing marble tiles in floors at locations shown on the Drawings in approved shades and colours. Unless otherwise specified, all marble work shall be in conformity with the latest British Code of Practice for this Work.

b. The marble tiles shall be from approved local source, uniform in color, texture, shade and quality.

c. Generally, marble tiles shall be 12‖x12‖x 1/2‖ and 24‖ x 24‖ x 3/4" or of size and thickness specified in the Drawings and Bill of Quantities.

### 15.06.2 Materials

a. Marble

- Marble shall be best quality Boticina marble, compact, dense, metamorphic rock of lime stone origin from quarries in Pakistan or elsewhere. It must be evenly grained with sugar like appearance. The shade and colors shall be to the approval of the Engineer.
- All marble tiles shall be totally free from cracks, defects, fissures etc. and shall have adequate strength to perform as required with good resistance against abrasion and shall have an abrasive strength not less than 20.

b. Portland cement conforming to BS 12.

c. White Cement conforming to relevant BS Specification.

d. Sand and aggregate shall comply with requirements of ASTM Specifications C- 33.

e. Water shall be clean potable drinking water, free from oils, acids, alkalis, and salts and organic or other injurious matter.

f. Pigments to be used shall comply with BS 1014.

### 15.06.3 Samples

a. The Contractor shall provide samples of marble tiles to be used for this item of Work showing the entire range of variation and colour for the selection and approval of the Engineer. The samples shall be in finished sizes and shape, thecost of which shall be deemed to be included in the rates. The approved samples shall be retained by the Engineer to form standards against which deliveries willbe judged.

b. The samples supplied shall conform to the ASTM standards stated below for the determination of the following:

| | |
|---|---|
| Weight % Absorption | ASTM C-97-47 |
| Modules of Rupture | ASTM C-99 |
| Compressive Strength | ASTM C-170 |
| Resistance to Abrasion | ASTM C-241-51 |
| Flexural Strength | ASTM C-8880-78 |

### 15.06.4 Bedding & Finishing

a. The Contractor shall employ skilled and trained marble workers for doing this job. The Contractor may be allowed to employ an approved specialist subcontractor for this item of Work. All Work shall be of the highest quality in conformance withthe Contract requirements and to the approval of the Engineer. Any substandard work shall be rejected and the Contractor shall remove and replace the same athis own cost.

b. The surface over which the marble tiles are required to be fixed shall be clean ofall dirt and dust and should be properly hacked so that the mortar sticks well to the surface.

c. The Contractor shall ensure that all the edges of tiles supplied at Site are at right angles to each other, unless other angles are required due to design requirements. The Contractor shall also ensure that all sizes are adequate for the Work as specified.

d. Damaged tiles or tiles with broken edges shall not be acceptable and in no case shall be used in the Work & shall immediately be removed from the Site.

e. Marble tiles shall be bedded on the wet screeding described above at 7.02.2 and 7.03 by applying a thin layer of neat cement paste on to the screed bed and the tiles placed in position and tamped down gently with a wooden mallet to be levelwith other tiles. The tiles shall be laid in the manner so that they align perfectly to the specified lines and levels and are square. The tile joints shall be as thin aspossible but not more than 2 mm wide and shall be regular and perfectly straight, and setting out shall be carried to ensure a minimum of cut tiles. Any tiles requiring to be cut shall be saw-cut by approved tools. Tiles pattern shall be square to the spaces floored, and any patterning by tile jointing, alternating colors, etc. is to be carried out as indicated on the Drawings and as approved bythe Engineer.

f. The surface during laying shall be frequently checked with a straight edge at least 2m long to obtain a true surface with dead level or slope, as directed.

g. All tile joints shall be grouted up solidly with a grout comprising of white Portland cement and water, all surplus to be cleaned off immediately.

h. Once bedded, curing shall be carried out by covering in hessian and continuous wetting for a minimum period of 3 days and the floor kept clear of traffic for at least 48 hours.

i. When cured, the marble tiling shall be polished with chemical polish to the approval of the Engineer. No wax polish shall be allowed. Polishing must be evenly and carefully carried out and a perfect smooth surface produced.

j. The marble shall be chemical polish finished to a glossy surface that will reflect light to emphasize the color and marking. All finished surfaces shall be of uniform texture, color and appearance.

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### 15.06.5 Dado

a. Dado in all marble tiled areas are to be in marble to match the floor tiling to the area concerned, unless specified otherwise. The dado shall be produced in an identical manner as for tiling. The dado shall normally be fixed to the walls up toheights shown in the Drawings with top edges arris-rounded or as shown on the Drawings or as approved by the Engineer.

b. The dado tiles shall be fixed to walls on a plastered backing having a slightly rough surface with neat cement paste. The back of each tile shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet so that the tile faces are set in one plane. The tiles shall then be grouted and polished with chemical polish as for marble floor tiling.

### 15.06.6 Marble Tread and Risers

Stair tread and riser slabs shall be provided in local ¯Boticina‖ marble or imported marble in approved color and shade and to sizes and profiles as indicated on the Drawings. Treads to be 1‖ thick in single pieces as shown on Drawings, length to suitstair widths, one long edge arris-rounded and polished, risers shall be ½‖ thick in single pieces of sizes to suit stair widths; ends polished. Treads and risers shall be bedded in screed as for tiling, of thickness as indicated, all level and square or to profiles shown on Drawings, chemical polished and finished.

### 15.06.7 Marble Counter Tops

Marble slabs to kitchen counters, toilet counters or others shall be provided to sizes and profiles as indicated on the Drawings. The marble tops shall be provided in configurations to suit the built-in cabinets as per approved shop drawings in approved shade and color, delivered to Site polished and finished to the approval of the Engineer. Marble tops for toilets shall be recessed to provide wash hand basins, where required.

## 15.07 CERAMIC FLOOR TILES

### 15.07.1 Description

The Work included in this sub-section shall comprise of providing and fixing in position locally manufactured ceramic floor tiles in approved sizes, color and pattern at locations shown on the Drawings and mentioned in the Bill of Quantities.

### 15.07.2 Materials

a. Ceramic floor tiles shall be local or imported or equal approved from local source. Ceramic floor tiles for bathrooms shall be non-skid.

b. The tile shall be bedded with neat cement paste or as recommended by the manufacturer to the approval of the Engineer.

c. Joint filler shall be white Portland cement grout which shall be non-shrinking, stain resistant, permanent in colors, and shall not inhabit fungus and bacterial growth. It shall be odorless and non-toxic, of smooth consistency for easy preparation and neat, rapid installation, and shall not contain any metallic material or ingredients. The joint floor grout shall be water resistant and shall not washout underwater.

d. Portland cement conforming to BS 12.

e. White Cement conforming to relevant BS standard.

f. Sand & aggregate shall comply with ASTM C33.

g. Water shall be clean potable drinking water, free from oils, acids, alkalis, salts and organic or other impurities and injurious matter.

h. Pigments to be used shall comply with BS 1014.

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### 15.07.3 Samples

The tile samples for local ceramic floor tiles shall be furnished from various product ranges of different manufacturers in sizes, patterns and colors for the selection and approval of the Engineer. The approved samples shall be retained by the Engineer to form standards against which deliveries will be judged.

### 15.07.4 Bedding, Laying & Jointing

a. Ceramic Tiles shall either be bedded on the hard set floor screeding describedabove at 7.02.2(b) and 7.03 by applying a thin layer of neat cement paste on tothe screed bed and the tiles placed in position and tamped down gently with a rubber mallet to be level with other tiles or directly on top of the M. S. plate with approved tile adhesive. The tiles shall be laid in the manner so that they align perfectly to the specified lines and levels and are square. The tile joints shall be as thin as possible but not more than 2 mm wide if spacer nibs not provided, and shall be regular and perfectly straight, and setting out shall be carried to ensure a minimum of cut tiles. Any tiles requiring to be cut shall be cut by approved tools. Tiles pattern shall be square to the spaces floored, and any patterning by tile jointing, alternating colors, etc. is to be carried out as indicated on the Drawings and as approved by the Engineer.

b. The surface during laying shall be frequently checked with a straight edge atleast 2m long to obtain a true surface with dead level or slope as directed. Tiles that are out of true plane or placed incorrectly shall be removed and reset.

c. All tile joints shall be straight, level and of even width throughout. The tile jointsshall be grouted up solidly in matching color with a grout comprising of white Portland cement or approved tile joint filler, pigment and water; all surplus to be cleaned off immediately.

d. Once bedded, curing shall be carried out by covering in hessian and continuous wetting for a minimum period of 3 days and the floor kept clear of traffic for at least 48 hours.

e. When cured, the floor shall be washed and cleaned to the approval of the Engineer.

### 15.07.5 Skirting

a. Skirting in all ceramic floor tiled areas are to be of ceramic tile to match the floortiling to the area concerned, as specified or shown on Drawings. The skirting shall be provided in an identical manner as for tiling. The skirting shall normally be 4‖ high with top edges arris-rounded or in the size and shape as shown on the Drawings or as approved by the Engineer.

b. The skirting shall be fixed to walls on a plastered backing having a slightly rough surface with neat cement paste. The back of each skirting tile shall be coveredwith a thin layer of neat cement paste and the tile shall then be gently tapped against the wall over rendered backing with a rubber mallet so that the tile faces are set in one plane. The skirting shall be grouted and finished as for ceramic floor tiles.

### 15.07.6 Dado

a. Dado in all ceramic floor tiled areas is to be in ceramic tiles to match the floor tiling to the area concerned, as specified or shown on Drawings. The dado shall be provided in an identical manner as for tiling. The dado shall normally be fixedon walls upto the heights shown in the Drawings with top edges arris-rounded or as shown on the Drawings or as approved by the Engineer.

b. The dado tiles shall be fixed to walls on a plastered backing having a slightly rough surface with neat cement paste. The back of each tile shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall over a rendered backing with a wooden mallet so that the tile faces are set in one plane. The dado shall be grouted and finished as for ceramic floor tiles.

## 15.08 QUARRY FLOOR TILES

The non-slip quarry tiles shall be in accordance to B.S. ASTM standard of sizes colors and design as indicated in the Schedule of Finishes. Square tiles shall be laid square with straight joints perfectly horizontal and vertical. Rectangular tiles shall be laid similarly to the square tiles or with broken joints to the tile face.

The preparation, Workmanship and protection are to be as described in the above Specification for Tiling work.

## 15.09 PORCELAIN FLOOR TILES

### 15.09.1 Description

The Work included in this subsection shall comprise of providing and fixing in position imported porcelain floor tiles of approved size, color and pattern at locations shown on the Drawings and mentioned in the Bill of Quantities.

### 15.09.2 Materials

a. Imported non-skid Porcelain Ceramic Floor Tiles shall be from RAK Ceramics,UAE, or equal approved to the approval of the Engineer in the specified size, color and pattern.

b. The tiles shall be bedded with neat cement paste or as recommended by the manufacturer and approved by the Engineer.

c. Joint filler grout shall be from the same manufacture. The grout which shall be non-shrinking, stain resistant, permanent in color, and shall not inhabit fungus and bacterial growth. It shall be odorless and non-toxic, of smooth consistency for easy preparation and neat, rapid installation, and shall not contain any metallic material or ingredients. The joint floor grout shall be water resistant and shall not washout underwater.

d. Portland cement conforming to BS 12.

e. White Cement conforming to relevant BS standard.

f. Sand & aggregate shall comply with ASTM C33.

g. Water shall be clean potable drinking water, free from oils, acids, alkalis, salts and organic or other impurities and injurious matter.

h. Pigments to be used shall comply with BS 1014.

### 15.09.3 Samples

The tile samples for the imported porcelain floor tiles shall be furnished from various product ranges of different manufacturers in sizes, patterns and colors for the selection and approval of the Engineer. The approved samples shall be retained by the Engineer to form standards against which deliveries will be judged.

### 15.09.4 Bedding, Laying & Jointing

a. Porcelain Tiles shall either be bedded on the hard set floor screeding describedabove at 7.02.2(b) and 7.03 by applying a thin layer of neat cement paste on the screed bed and the tiles placed in position and tamped down gently with a

rubber mallet to be level with other tiles. The tiles shall be laid in the manner so that they align perfectly to the specified lines and levels and are square. The tile joints shall be as thin as possible but not more than 2 mm wide, and shall be regular and perfectly straight, and setting out shall be carried to ensure a minimum of cut tiles. Any tiles requiring to be cut shall be cut by approved tools. Tiles pattern shall be square to the spaces floored, and any patterning by tile jointing, alternating colors, etc. is to be carried out as indicated on the Drawings and as approved by the Engineer.

b. The surface during laying shall be frequently checked with a straight edge at least 2m long to obtain a true surface with dead level or slope as directed. Tilesthat are out of true plane or placed incorrect shall be removed and reset.

c. All tile joints shall be straight, level and of even width throughout. The tile jointsshall be grouted up solidly in matching color with approved tile joint filler and water; all surpluses to be cleaned off immediately.

d. Once bedded, curing shall be carried out by covering in hessian and continuous wetting for a minimum period of 3 days and the floor kept clear of traffic for at least 48 hours.

e. When cured, the floor shall be washed and cleaned to the approval of the Engineer.

### 15.09.5 Skirting

a. Skirting in all porcelain ceramic floor tiled areas are to be of porcelain tiles to match the floor tiling to the area concerned, as specified or shown on Drawings.The skirting shall be provided in an identical manner as for tiling. The skirting shall normally be 4‖ high with top edges arris-rounded or in the size and shapeas shown on the Drawings or as approved by the Engineer.

b. The skirting shall be fixed to walls on a plastered backing having a slightly rough surface with neat cement paste. The back of each skirting tile shall be coveredwith a thin layer of neat cement paste and the tile shall then be gently tapped against the wall over rendered backing with a rubber mallet so that the tile faces are set in one plane. The skirting shall then be grouted and finished as for porcelain tiling.

### 15.09.6 Protection

The completed Works or parts thereof shall be protected by the Contractor against any damage. The Works shall be handed over in perfect condition. If any damage is incurred then the Contractor shall remove and/or replace the same at no additional costs. The Contractor shall exercise all care to protect the works executed by other trades and not covered by his Contract. Any damage to these shall be made good andthe works restored at no additional cost.

## 15.10 VINYL FLOOR TILES

### 15.10.1 Description

The Work included in this subsection shall comprise of providing and fixing in position imported Vinyl floor tiles of approved size, color and pattern at locations shown on the Drawings and mentioned in the Bill of Quantities.

### 15.10.2 Materials

#### a. Vinyl Floor Tiles

Imported non-skid Vinyl Floor Tiles shall be from Armstrong/ Marle or equal approved to the approval of the Engineer in the specified size, color and pattern.

b. The tiles shall be laid with Adhesive or as recommended by the manufacturer and approved by the Engineer.

### 15.10.3 Samples

The tile samples for the imported Vinyl floor tiles shall be furnished from various product ranges of different manufacturers in sizes, patterns and colors for the selection and approval of the Engineer. The approved samples shall be retained by the Engineer to form standards against which deliveries will be judged.

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### 15.10.4 Bedding, Laying & Jointing

a. Vinyl Tiles shall be laid on the hard set floor screeding described above at 7.02.2(b) and 7.03 by applying a thin layer of Adhesive on to the screed bed and the tiles placed in position and tamped down gently with a rubber mallet tobe level with other tiles. The tiles shall be laid in the manner so that they align perfectly to the specified lines and levels and are square. The tile joints shall beas thin as possible and shall be regular and perfectly straight, and setting out shall be carried to ensure a minimum of cut tiles. Any tiles requiring to be cut shall be cut by approved tools. Tiles pattern shall be square to the spaces floored, and any patterning by tile jointing, alternating colors, etc. is to be carried out as indicated on the Drawings and as approved by the Engineer.

b. The surface during lying shall be frequently checked with a straight edge at least 2m long to obtain a true surface with dead level or slope as directed. Tiles that are out of true plane or placed incorrect shall be removed and reset.

c. All tile joints shall be straight, level and of even width throughout. The tile joints shall be cleaned with approved cleaner tile, all surpluses material to be cleaned off immediately.

### 15.10.5 Skirting

a. Skirting in all Vinyl floor tiled areas are to be of Vinyl coved skirting to match thefloor tiling to the area concerned, as specified or shown on Drawings. The skirting shall be provided in an identical manner as for tiling. The skirting shall normally be 4‖ high with top edges arris-rounded or in the size and shape as shown on the Drawings or as approved by the Engineer.

b. The skirting shall be fixed to walls on a plastered backing having a smooth surface with Adhesive.

## 15.11 THERMOPORE SHEETS

The material shall be of approved manufacture and of best quality available in Pakistan. The thermopore shall be of the type used for insulating roof, on sides of and under generator, transformer pads.

The insulation shall conform to the following physical requirements:-

| | |
|---|---|
| Density (Average) Lbs. per Cft | 6 to 8.5 |
| Specific Gravity (Average) | 0.12 |
| Flexural Strength (Average Kgm per Sq. Cm.) | 3.6 to 4.3 |
| Impact Strenth (Cm/Kgm per Sq. Cm.) | 0.3 to 0.7 |
| Compressive strength (Cm/Kg per Sq. Cm) | 0.17 to 1.44 |
| Deflection (Average) | 0.25 to Inches |
| Thermal conductivity (Average)<br>Maximum BTU at mean temperature 10 Degree F. | 0.22 |

## 15.12 CORK BOARD SHEETS

The material shall be of approved manufacture and of best quality available in Pakistan. The Cork sheet shall be of the type used as gasket material on sides of and under generator, transformer pads.

The insulation shall conform to the following physical requirements:-

| | |
|---|---|
| Density (Average) kg/m³ | 400-1500 |

| | |
|---|---|
| Flexural Strength (Average MPa.) | 0.5-4.0 MPa |
| Compressive strength (Average MPa) | 1 - 26 |
| Hardness | 70-80 |
| Acoustic resistivity, kg $m^{-2}$ $s^{-1}$ | 1. 26105 |
| Thermal conductivity (Average) W $m^{-1}$ $K^{-1}$. | 0.045 |

## 15.13 MEASUREMENT AND PAYMENT

Floor tiling works covered by this section of Specifications, complete and approved, will be measured and paid for per square meter, at the individual item rates entered in the Bill of Quantities and generally in accordance with the applicable terms and conditions of the Contract.

Skirting, treads and risers shall be measured and paid for per running meter at the individual item rates entered in the Bill of Quantities, as per terms stated above.

*** END OF SECTION***

## SECTION - 16
## PAINTING

### 16.01 SCOPE OF WORK

The work under this section of the Specifications consists of furnishing all materials, plant, labor, equipment, appliances and performing all operations in connection with surface preparation, mixing, painting concrete works, gates, grills, frames, walls, ceilings and all such surfaces as shown on the Drawings and/or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

### 16.02 APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications wherever applicable.

**BSI (British Standards Institution)**

BS 245 -- Specification for mineral solvents (white spirits and related hydrocarbon solvents) for paints and other purposes.

BS 2521 -- Lead-based priming paint for woodwork.

BS 2522 -- Lead based priming paint for iron and steel.

BS 2569 -- Sprayed metal coatings. Paint colors for building purposes

CP 231 -- Painting of building

CP 3012 -- Cleaning and preparation of metal surfaces.

### 16.03 GENERAL

16.03.1 Except as otherwise specified, all painting shall be applied in conformity with BS CP 231 "Painting of Building" as applicable to the work.

16.03.2 The Contractor shall repair at his own/expense all damaged or defective areas of shop-painted metal work and structural steelwork. Metal surfaces against which concrete is to be placed will be furnished shop-painted and shall be cleaned to being embedded in concrete.

16.03.3 Except as otherwise specified, all concrete and plastered surfaces are to be painted.

16.03.4 The Engineer will furnish a schedule of colors for each area and surface. All colors shall be mixed in accordance with the manufacturer's instructions.

16.03.5 Colors of priming coat (and body coat where specified, shall be lighter than those of finish coat. The Engineer shall have unlimited choice of colors.

16.03.6 Samples of all colors and finishes shall be prepared in advance of requirement soas not to delay work and shall be submitted to the Engineer for approval before any work is commenced. Any work done without such approval shall be redone to the Engineer's satisfaction, without additional expense to the Employer, samples of each type of paint shall be on separate 1 ft. x 1 ft. x 1/8 inch tempered hard hoard panels. Manufacturer's color chart shall be submitted for color specificationsand selection.

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## 16.04 MATERIALS AND EQUIPMENT'S

16.04.1 All materials shall be acceptable, proven, first grade products and shall meet or exceed the minimum standards of approved manufacturers.

16.04.2 Colors shall be pure, non-fading pigments, mildew-proof, sun-proof, finely ground in approved medium. Colors used on plaster and concrete surfaces shall be lime-proof. All materials shall be subject to the Engineer's approval.

16.04.3 Approved quality Distemper paint shall be used for painting where specified on the drawings as directed by the Engineer.

16.04.4 The plastic emulsion/weather shield paint or similar as approved by the Engineer shall be used where specified on the drawing as directed by the Engineer.

16.04.5 Other materials/ equipment's to be used are;

- Cement primer, Turpentine, Putty, Polish paper, Wood primer, Emerypolish paper and Water
- Drop cloth and polythene sheets of suitable size & quality shall be used to protect other materials and surfaces.
- The masking material where-ever necessary shall be used in sufficient quantities to avoid falling of paint on unwanted surfaces.
- Grinding / buffing wheels, w ire brush & emery paper.
- Electrical distribution panels switch boards & hand lamps.
- Kerosene, thinners, acetone etc. to remove oil / grease etc.
- Painting brush:
- Good quality brushes with long and flexible bristles free from any paint residue shall be used.
- Neat, clean & painted scaffoldings of good quality.
- Good quality ladders, platforms etc.
- Safety gears to be used by personnel like respirator, face mask, hand gloves, protective clothing etc.

All material shall be delivered to site in their original unbroken containers or packages and bear the manufacturer's name, label, brand and formula and will be mixed and applied in accordancewith his directions.

## 16.05 DELIVERY STORAGE AND CONTAINER SIZES

Paints shall be delivered to the site in sealed containers which plainly show the type of paint, color (formula or specifications number) batch number, quantity, and date of manufacture, name of manufacturer and instructions for use. Pigmented paints shall be supplied in containers not larger than 20 liters. All materials shall be stored under cover in a clean storage space which should be accessible at all times to the Engineer. If storage is allowed inside the building, floors shall be kept clean and free from paint spillage.

## 16.06 SURFACE PREPARATION

a. All oil, grease, dirt, dust, loose mill scale and any other foreign substance shall be removedfrom the surface to be painted, polished and white washed by the use of a solvent and clean wiping material. Following the solvent cleaning, the surfaces shall be cleaned by scrapping, chipping, blasting, wire brushing or other effective means as approved by the Engineer.

b. All the surfaces to be painted shall be free from dust, dirt, fungus, lichen, algae etc. old paint, varnish and lime wash should always be removed by scraping and washing.

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c. All surfaces shall be made smooth, prior to the application of primer by rubbing with Bathy (silicon carbide rubbing brick) and/ or sand paper, filling the voids putty (Zinc/ Chalk/ Plaster of Paris mixture).

d. In the event the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning will be done by the Contractor at no additional cost.

e. No work in this section shall be allowed until all surfaces or conditions have been inspected and approved by the Engineer.

## 16.07 APPLICATION

All paint and coating materials shall be in a thoroughly mixed condition at the time of application. All work shall be done in a workman like manner, leaving the finished surface free from drips, ridges, waves, laps, and brush marks. All paints shall be applied under dry and dust free conditions, Unless approved by the Engineer paint shall not be applied when the temperature of the metal or of the surrounding air is below 7 degrees centigrade, Surfaces shall be free from moisture at the time of painting.

All primary paint (Alkali Resistance) shall be applied by brushing. The first coat of paint shall be applied immediately after cleaning. When paint is applied by spraying, suitable measures shall be taken to prevent segregation of the paint in the container during painting operation.

Effective means shall be adopted for removing all free oil and moisture from the air supply lines of the spraying equipment.

A priming coat shall be applied to the cleaned and smooth surfaces first. Unless otherwise specified in the BOQ or approved by the Engineer, all surfaces shall have at least 3 coats of paint in addition to the priming coat.

Each coat of paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation shall be completely painted prior to installation. Only as much material should be mixed as can be used up in one hour. Over-thinning will not be permitted. After the first coat the surfaces will be soaked evenlyfour or five times and the second coat shall be applied after leaving for at least overnight.

a. Where shown on Drawings all exterior finishes shall be painted with weather resistant paint in approved colors as per manufacturer's specifications.
b. For Interior finishes on concrete, masonry, door, windows, cabinets, grills etc. any of the listed types of paints, i.e.; Whitewash, Oil, Plastic or Matte Emulsion, Cement-based, Enamel, Distemper, Textured, Bituminous, Epoxy, Anti-condensation, Luminous (fluorescent), Latex, Lead, Metallic, Rubber, Aluminum, Silicone, Zinc rich, Anti-corrosive, Fungicidal Paint of the approved make and shade shall be applied to surfaces as shown on Drawings or as specified by the Engineer.

Walls, floors & ceiling and adjacent equipment‘s and piping shall be satisfactorily protected by drop clothes. Other precautionary measures should be taken during spray / brush painting to ensure at surrounding area /equipment is not affected.

The application should be as per manufacturer‘s instructions / specifications. Before opening the packed drum, it should be rolled on the floor and after opening the drum paints shall be stirred well so that no material/ pigments remains settled at the bottom. Suitably of the paintshall be checked as per requirement before opening.

The choice of method of application i.e. by brush or by spray gun will be decided by the Engineer. However, adjacent equipment / structures shall be suitably protected and care shall be taken to prevent intoxication of the surrounding area. The method of paint application depending upon the area shall be jointly discussed and decided with Engineer. Paint thickness(DFT) shall be as per the item scheduled. In case the dry film thickness of finish paint is observed less than the specified values, additional coat shall have to be applied free of charge.

**Polishing**

After fine sanding by a skilled operator, one coat of clear polish should be rubbed in by hand using a cloth or pad, be allowed to dry and buffed up with worn fine sand paper or steel wool to remove raised grain. A second coat of clear polish should then be applied.

## 16.08 JOB CONDITIONS

16.08.1 Observe manufacturer's recommended minimum and maximum temperature but do not apply paint or finish to any surface unless ambient temperature is 10 degree C or above and less than 43 decree C. No painting shall be done above 90% relative humidity.

16.08.2 Adequately protect all finished work.

16.08.3 Remove and replace all items of finish hardware, device plates, accessories, lighting fixtures or other removable items.

16.08.4 In no case shall any finish hardware or other finished item that is already fitted intoplace be painted, unless otherwise specified.

## 16.09 Inspection & Check :

All the work is subject to the inspection of the Engineer or his authorized representative which shall be carried out in a manner, satisfactory to the Engineer. The contractor shall rectify any short comings pointed out by the said representative. The general inspection requirements areas follows:-

a. No paint shall be applied until the authorized inspection has ascertained that all prepared surfaces are satisfactorily cleaned and are in a condition to ensure the proper receipt of and adhesion of the coating.
b. The contractor shall furnish all gauges, instruments and the necessary measuringequipment‘s required for inspecting the work, test pieces, samples etc. at site and in the shop. The Engineer‘s authorized representative is intended to ensure that the material and workmanship are in accordance with this specification, but it will not relieve the contractor for any of his responsibilities for the ultimate workmanship and performances.

## 16.10 QUALITY ASSURANCE

All paint for any one surface shall be top quality, of one manufacturer of the specified. Deep tone accent colors shall be used and the unavailability of final coat colors may be the basis forrejecting materials for any one surface.

## 16.11 MEASUREMENT AND PAYMENT

All the painting and finishing on all surfaces, other than timber and steelworks which shall be deemed to be inclusive of painting and finishing in their own items of works, shall be measured per square Meter/ft in accordance with standard method of measurement and paid for at the unit rates entered in the Bill of Quantities and in accordance with the terms and conditions of this Contract.

Where separate quantities are not shown in the Bill of Quantities, these shall be deemed to have been included in the rate of the relevant items to be finished and painted and no separate payment shall be made for painting/finishing works of such items.

*** END OF SECTION ***

# SECTION - 17
# MISCELLANEOUS METAL WORK

## 17.01 SCOPE OF WORK

The Work covered in this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the fabrication and installation of miscellaneous metal works, complete in strict accordance with this section of the Specifications and the applicable Drawings and subject to the terms and conditionsof the Contract.

## 17.02 GENERAL

All metal shall be well formed to shape and size, with sharp lines or angles. Shearing and punching shall be left clean to true lines and surfaces. Shop connections shall be welded or riveted and site connections bolted unless otherwise noted. Use flat headed countersunk rivets where riveted connections are exposed to view in finished work. Bolts shall be turned up tight and threads nicked to prevent loosening. All bolts shall be provided with washers.

For exposed connections with hair line joints which are flush and smooth, concealed fasteners shall be used wherever possible. If exposed fasteners are unavoidable, use countersunk flatheadscrews or bolts.

All metals shall be free from corrosion, scale, distortion and other damage, and only new materialshall be used for fabrication purposes.

## 17.03 MATERIALS

### 17.03.1 Steel

a. All steel sections shall comply with BS 4, parts 1 and 2, and BS 4848. Steel shall be mild steel complying with BS 4360, Grades 43A, 43B and 43C as appropriate.

b. Steel tubes for structural and general engineering purposes shall comply with BS 1775.

c. Steel tubes and tubulars for balustrades shall comply with BS 1387 designation of either light, medium or heavy and the steel pipe fittings shall comply with BS 1740.

d. Galvanized MS tube shall comply with BS4 and BS 1387 medium grade.

e. Stainless steel sections shall be to BS 970, quality En. 58A. stainless steel pipesshall be to BS 3605.

f. All steel shall be supplied from a specifically approved source, from approved manufacturers, and certificates of origin and mill test certificates shall be supplied in all cases, proof of compliance with the relevant standards shall be a condition of approval.

### 17.03.2 Nuts, Bolts and Screws

a. Nuts and bolts etc. shall comply with BS 4190 and BS 1494 and shall have SI metric threads complying with BS 3643.
b. Stainless steel bolts are to be set bolts and shall comply with BS 4190. The stainless steel for bolts, nuts and washers shall comply with BS 970, quality En 58 A.M.
c. Self-tapping screws shall comply with BS 4194.

## 17.04 COORDINATION WITH OTHER TRADES

a. All work under this section shall be coordinated with the work to be done as specifiedunder other sections of the Specifications and as well as with other trades.

b. The Contractor shall furnish all information and instructions required for work by other trades.

c. The Contractor shall drill, tap, cut and fit the work included herein as required to accommodate work of other trades in conjunction with it.

d. The Contractor shall be responsible for obtaining exact site dimensions and accurate execution of all parts of the work specified.

e. All the works shall be carried out exactly in accordance with the approved shop drawings.

## 17.05 SAMPLES

Samples or materials specified shall be submitted for approval when required by the Engineer.

## 17.06 FABRICATION

### 17.06.1 General Fabrication

a. All steel and other metals are to be cut, drilled, formed, bent, worked and otherwise fabricated to the details, forms and dimensions indicated on the approved shop drawings; setting out joints and fixings are to be such as to produce finished components that are perfectly square, sound and rigid. All members are to be of the sizes specified, and no alterations, additions or omissions in the size or arrangements of members may be made without Engineer's approval. The inclusion of gussets, bracing plates, fixing lugs, spacers, packings, etc. in the interests of rigidity or ease of fixing may be considered, but on a specific approval from the Engineer.

b. All open-ended members, including hollow sections, shall be capped off with welded plates or caps; no hollow surfaces which cannot be galvanized ormaintained are to be left exposed to atmosphere, whether shown so on Drawingsor not.

c. The provision of BS 449 shall apply generally to fabrication workmanship.

### 17.06.2 Joints

All steel joints specified as welded shall be cleanly and solidly welded, in general accordance with the provisions of BS 5135, using electrodes as specified in BS 639. All welds shall be continuous, solid, with no spot welding, and shall be ground off smooth flush and perfect on completion.

All joints specified as bolted, screwed or otherwise mechanically connected shall be properly set out to provide sufficient but not excessive tolerance, holes drilled accurately, and then soundly and solidly connected. All bolts, screws and connectors shall be either hot-dipped galvanized steel, stainless steel or non-ferrous metal, no untreated steel fixing device is to be used in any circumstances. Fixings shall be selected suitable for the particular purposes, and Engineer's approval obtained.

### 17.06.3 Tolerances

All metalwork shall be fabricated to overall dimensions so as to provide sufficient but not excessive tolerances between the components and adjoining work, and between adjoining metal components, bearing in mind building materials tolerances, thermal expansion, erection distortions and all other factors.

### 17.06.4 Drawings and Calculations

Detailed fabrication and shop drawings and, where appropriate, structural calculations shall be prepared by the Contractor for the approval of the Engineer for all the fabricated components. These shall be approved before commencement of work and should indicate all connections, fixing, methods of fabrication, and all other relevant details.

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### 17.06.5 Finishes and Protection

All steel and other metal components specified for painting shall be finished in a smooth workmanlike fashion, free of irregularities of surface, burrs, galvanizing excess, mill marks, oil, grease, dirt, etc. ready for painting.

All metalwork shall be protected during transportation delivery, storage on Site, and after erection, by such measures as shall be agreed with the Engineer, to prevent damage of any type, in particular scratching, denting, distortion, and other mistreatment. Materials so damaged will not be acceptable, and shall have to be replaced.

### 17.06.6 Riveting

Riveting where exposed shall be flush unless otherwise indicated on Drawings or directed by the Engineer.

### 17.06.7 Bolting

Bolting, where permitted, shall be done with proper size bolts. Nuts shall be drawn tightand thread nicked.

### 17.06.8 Steel

The use of Structural Steel in Buildings shall comply with BS 449 Part 2.

### 17.06.9 Welding

a. Welding of all steel shall comply with BS 5135. All welded joints which will be exposed shall be ground to a smooth finish. All welding shall be executed by experienced certified welders.

b. Welding shall be continuous except where tack-welding is specifically permitted.Tack welding will not be permitted on exposed surfaces.

c. Where galvanized items are to be welded, the weld and joint shall be ground smooth. Only complete welded assemblies may be hot pip galvanized. No cold galvanizing paint permitted cold galvanizing zinc.

d. No black bolts will be accepted. Only H.D. galvanized bolts shall be allowed.

### 17.06.10 Shop Finishing

a. Provide a 6 micron thick zinc coating for the items shown or specified to be galvanized using the hot dip process after fabrication.

b. Shop paint all ferrous metalwork except galvanized work and those portions of items which are to be embedded in concrete or masonry and surfaces and edges which are to be site welded.

c. Remove scale, rust and other deleterious materials before the shop coat of paint is applied.

d. Immediately after surface preparation, anticorrosion metal primer paint be applied in accordance with the manufacturer's instructions. Use painting methods which will result in full coverage of joints, corners, edges and all exposed surfaces.

### 17.06.11 Installation

a. Provide anchorage devices and fasteners where necessary for securing to finished work including threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, rag-bolts, wood screws and other connectors as necessary.

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b. Cut, drill and fit as necessary for installation. Set the work accurately in location, alignment and elevation, plumb, level and true. Provide temporary bracing or anchors in formwork for items which are to be cast or built into concrete, masonry or similar construction. Form right joints with exposed connections accurately fitted together. Do not cut or abrade members with finishes which cannot be completely restored on Site. Where cutting, welding and grinding are required for fitting and jointing of the work, restore finishes to eliminate any evidence of such corrective work.

c. Carry out all welds and carefully make good on completion.

d. Immediately after erection, clean all site welds, bolted connections and rough areas of the shop paint and coat all exposed areas with the same material as used for shop painting.

e. No site welding to galvanized item will be permitted.

### 17.06.12 Storage and Handling

a. All items described under this Section shall be handled, delivered and stored in a manner that will avoid damage, rust or deformation. Items shall be stored off- ground and shall be entirely covered with weatherproof coverings in storage area.

b. Items which become rusted or damaged because of non-compliance with these conditions will be subject to rejection, and such items shall be replaced without additional cost to the Employer.

### 17.06.13 Protection

a. Before arriving on Site, all surfaces of hot-dip galvanized method which are damaged, have rough spots or joints may be permitted to be by the Engineer be touched up, using an approved zinc primer coat. Damaged hot dip galvanized components will however generally be rejected. Primer shall be compatible for finish paint. Hot dip galvanized items shall not receive a shop coat of primer so that there may be a visual inspection on Site of such items by the Engineer.

b. Thoroughly insulate all non-ferrous items in contact with dissimilar metals, concrete, masonry and mortar with approved zinc-chromate coating or plastic membrane on contact surfaces before installation.

## 17.07 MISCELLANEOUS ITEMS

### 17.07.1 Hollow Metal Frames and Doors

Metal doors shall comprises of M.S. frames and shutters. All shapes and sizes of complete unit as well as components shall be strictly in accordance with details shown on the Drawings, fabricated, painted and fixed to hollow metal frame as per details shown on the Drawings.

a. Frames

i. All hollow metal frames shall be fabricated using 16 gauge M.S. sheets of best quality, free from all defects, and in accordance with the detailsindicated on the Drawings and Bill of Quantities.

ii. Frames shall be constructed as full welded units from approved manufacturers as per approved shop drawings.

iii. All corners mitred and back-welded and any exposed welds at all joints ground and dressed smooth.

iv. Anchors shall be provided as per approved details, 9‖ long, three to jambs and welded to frame at shop for embedding in block work.

v. All frames shall have channel spreaders. Frames cut, reinforced, mortised,drilled

and tapped as required for application of all hardware. All frames shall be fabricated as per final approved hardware schedule.

vi. Rubber/Neoprene bumper or sound absorbers shall be installed 3 per strikejamb.

vii. All contact edges shall be closed tight.

viii. Finished work shall be strong and rigid, neat in appearance and free from defects, warps, bulges or buckles. Moulded members shall be clean-cut straight with true edges.

ix. All cut-outs shall be protected against mortar or plaster with mortar guards of approved gauge.

x. After the frame is fabricated, all tool marks shall be ground smooth, all exposed surfaces degreased and thoroughly cleaned of rust, oil and other impurities and coated with approved primer to enable the surface of the metal to resist corrosion and promote paint adhesion. The remaining irregularities specially welding shall be dressed smooth.

b. **Doors**

Single or double leaf doors shall be fabricated from 20 gauge M.S. sheets of best quality and free from all defects and in accordance with the details indicated on the Drawings and Bill of Quantities.
The doors shall be manufactured from approved manufacturer as per the approved shop drawings. The door shall be provided with hinges and ready to receive locks etc.

c. **Installation**

i. Doors and frames that are fabricated and brought on the Site shall be approved by the Engineer before installation. Any defective or substandard work shall not be acceptable.
ii. Doors and frames shall be installed in accordance with the manufacturer‘s drawings and recommendations, all to the satisfaction of the Engineer.

d. **Painting**

i. One coat of anti-corrosion primer paint shall be applied to all exposed surfaces before the door and frame is installed. After this another base coat of enamel paint should be given.
ii. After the door and frame has been installed properly, three coats of enamelpaint of an approved quality and shade shall be finally applied to all exposed surfaces.

e. **Storage and Handling**

The Contractor shall be responsible for storage, handling and protection of the material on the job. Scratches, holes, dents and nicks and other marring of thepaint film will have to be made good and touched up without any extra cost.

### 17.07.2 Pipe Handrail

M.S. pipe hand rail shall be fabricated and installed, as per details indicated on Drawings & Bill of Quantities, by approved manufacturers in accordance with approved shop drawings. The pipe handrail shall be of 2 ½‖ dia M.S. balusters, M.S. fixing brackets/plates and screws etc., painted and installed.

### 17.07.3 M.S. Ladder

M.S. ladder shall be fabricated and installed, as per details indicated on Drawings & Bill of Quantities, by approved manufacturers in accordance with approved shop drawings.

## 17.08 MEASUREMENT AND PAYMENT

Metal doors shall be measured per square meter and paid for at the unit rates entered in the Bill of Quantities, inclusive of hollow metal frame, anchors, hardware, painting, installation, complete in all respect.

M.S. pipe handrail shall be measured per-running foot and paid for at the unit rate entered in the Bill of Quantities, inclusive of M.S. balusters, M.S. fixing brackets / plates, screws etc., painting and installation, complete in all respect.

M.S. ladder shall be measured and paid for at the unit rate entered in the Bill of Quantities, inclusive of all materials etc., painting and installation, complete in all respect.

*** END OF SECTION ***

## SECTION - 18
## UPVC DOORS AND WINDOWS

### 18.01 SCOPE OF WORK

The UPVC work as scheduled and detailed shall be fabricated as per the Drawings. Fabricated UPVC work covered by this specification shall be supplied and installed by the well-known local UPVC fabricators or manufacturer as approved by the Engineer.

Before placing any orders the Contractor shall state the name of the window manufacturer he has selected from the list of approved manufacturers. The nominated manufacturer shall not be changed without prior approval of the Engineer.

### 18.02 MATERIAL

Polyvinyl chloride Resin suspension grade is the basic raw material for forming PVC compound. PVC resin then is mixed with chemicals like Calcium, Stearate, Hydrocarbon Wax, Titanium Dioxide, Calcium Carbonate, and Acrylic processing aids. Further, additives like impact modifiers, pigments, epoxy plasticizer, UV stabilizer, lubricants, chemical blowing agent etc. are added. The purpose of adding the chemicals and additives is to impart cellular structure, strength, surface finish, color and resistance to fading by light rays. These chemicals are mixed in the desired proportion and shall be used in the formulation of PVC material and for free and smooth extrusionof PVC profiles.

### 18.03 MANUFACTURE

UPVC work shall be fabricated in accordance with the standard Manufacturer manual and as per the Drawings showing jointing details, hardware and extrusion profiles. It will be the UPVC fabricator's responsibility to ensure that all fabricated UPVC work is carried out in accordance with the Drawings. The frame and the rebate shall be a monolithic unit. All the members shall be free of stains and any damage. If any damage or defects during delivery or after fitting in positionare found, the defects shall be rectified immediately or replaced at the Contractor‘s expense. The Contractor shall attach all necessary product and quality specification along with the quotation.

All the frames and shutters shall be of the same color.

### 18.04 THE FLY MESH NET:

If applicable, shall be stainless steel jali (fly mesh net) or as approved by the A/E. The jali shall be fitted neatly and cleanly in the shutter and shall be tight and plain throughout the shutter. Any damage during fitting or delivery will not be accepted. The Contractor shall replace the fly mesh immediately at no additional cost if the fly mesh is found to be damaged after fitting and fixing in position.

The contractor shall verify the exact dimension at site before fabrication. In the event of any changes, the Contractor shall be timely informed by the UPVC contractor (in the event of third party supply) at the time of masonry works. Any demolition and/or re-masonry work due to the lack of co-ordination between the UPVC contractor and the civil contractor will be the responsibility of the Contractor and it is incumbent on the Contractor to co-ordinate, as appropriate, with the UPVC.

### 18.05 DOUBLE GLAZING

Insulating glass (IG), more commonly known as double glazing or double-pane, consists of two glass window panes separated by a vacuum or gas filled space to reduce heat transfer across a part of the building envelope.

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Insulating glass units (IGUs) are manufactured with glass in range of thickness from 3 to 10 mm (1/8" to 3/8") or more in special applications. Laminated or tempered glass may also be used as part of the construction. Most units are produced with the same thickness of glass used on both panes but special applications such as acoustic attenuation or security may require wide ranges of thicknesses to be incorporated in the same unit.

## 18.06 WORKSHOP DRAWINGS

The contractor shall arrange for the preparation of complete workshop drawings of all fabricated UPVC work and shall submit same to the Engineer for approval.

## 18.07 FLASHING

All flashings required to be built in as the work proceeds shall be supplied by the Contractor and built in by the trade concerned. All other flashings as detailed on the Drawings shall be supplied and fixed in position by the fabricator.

## 18.08 HARDWARE FITTINGS

Hinges, handles, knobs, locks, ball catchers, bolts, door stoppers, door closers, door spring adjustable shelf fittings and other hardware fittings for doors and windows shall be of the best quality and of the specified make and approved by the Engineer. The size number, make etc. shall be as per the hardware schedules as shown on drawings or BOQ.

## 18.09 MEASUREMENT& PAYMENT

It shall be done in square meter of the area done. Rate shall be for all labour and materials, accessories, all complete

*** END OF SECTION ***

# SECTION - 19
# WALL TILING

## 19.01 SCOPE OF WORK

The Work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with providing and laying of wall tiles, complete in strict compliance with this section of Specifications, the applicable Drawings and in accordance with the terms and conditions of the Contract.

## 19.02 GENERAL

Best quality local or imported wall tiles from approved manufacturers in approved size, color and pattern at locations shown on the Drawings and in the Bill of Quantities shall be supplied and laid dully approved by the Engineer.

## 19.03 MATERIALS

Tile can be from of any of the types listed below:

Ceramic tiles, Porcelain tiles, Marble tiles, Granite tiles, Cement tiles, Vitrified tiles, Glass Tiles, Mosaic Tiles, Travertine tiles, Slate Tile, Quartizite Tiles etc.

a. All the tiles shall be perfectly true to shape, flat, free from crazing, walks and other flaws and shall be consistent in color and pattern equal to samples presented to the Engineer for approval. The bedding faces of all tiles shall be keyed to an approved pattern.

   Except as otherwise specified, the following British Standards and Code of Practice shall be applicable to materials and fixing methods for ceramic tiles:

i. British Standard 1281: 1966 ¯Glazed Ceramic Tiles and Tile Fittings for internal wall‖.

ii. British Standard CP 212: for fixing methods and workmanship.

b. Adhesives for ceramic tiling shall be neat cement paste or as recommended by the tile manufacturer.

c. Joint Filler shall be white Portland cement grout in matching colour which shall be non-shrinking, stain resistant, permanent in colour, and shall not inhabit fungus and bacterial growth. It shall be odorless and non-toxic, of smooth consistency for easy preparation and neat, rapid installation, and shall not contain any metallic material or ingredients. The joint grout shall be water resistant and shall not wash out under water.

d. Portland cement conforming to BS 12.

e. White Cement conforming to relevant BS Specifications.

f. Sand shall comply with ASTM C-33.

g. Water shall be clean potable drinking water, free from oils, acids, alkalis, salts and organic or other injurious matter.

h. Pigments to be used shall comply with BS 1014.

## 19.04 SAMPLES

All wall tiles materials such as ceramic tiles etc. to be used in the Works shall receive prior approval of the Engineer.

The Contractor shall submit adequate number of samples of tiles from the product ranges of different local manufacturers for the selection and approval of the Engineer. The approved samples shall be kept by the Engineer to form standards against which all deliveries will be judged.

The Contractor shall strictly follow the instructions of the manufacturers and the wall finishes shall be applied accordingly.

Wall tiling to internal and external walls and fascia shall be fixed true to the line level and plumb in approved manner satisfactory to the Engineer. All tiles shall be aligned properly with straightjoints in even widths.

Any work covered under this section of the Specifications, not conforming to the requirements of the specified quality and workmanship will not be acceptable and shall be rejected by the Engineer, and the Contractor shall be required to remove and replace such work without any claim at his own cost as per the instructions of the Engineer.

## 19.05 BEDDING AND JOINTING

a. The tiles shall be fixed to the walls over a rendered backing as described below:

Rendered Backing

The tiles to be fixed to walls shall be fixed on a rendered backing. Walls to be tiled areto be prepared exactly as for rendering/plastering. A 10 mm thick cement sand render coat shall then be applied exactly as described for plastering in a ratio of 1:4. The surface to be scratch-keyed as approved and particular attention to be given to curing. The tiles shall be fixed to this rendered backing with a paste of cement.

b. Surfaces to receive the ceramic tiling shall be clean and free of dirt, dust, oil, grease orother objectionable material.

c. After having been immersed in clean water for a minimum of 7 hours, until saturated the tiles shall then be bedded in a bedding coat of cement paste, all to the approval and instructions of the Engineer.

d. Tiles shall be set out carefully and bedded to a true vertical face, square and plumb, aligned in accurate continuous horizontal and vertical courses to an un-bonded patternso as to give regular joint widths of approx. 2 mm if spacer nibs are not provided.

e. Tiled areas shall be cured when set by continuous wetting for a minimum period of 3 days.

f. When cured, tile joints shall be pointed with a liquid neat white Portland cement grout in matching color so as to fill each joint solidly and continuously. When set, joints shall be finger-smoothed off to an even concave profile.

g. Tiles where required to be cut shall be marked off and cut with approved tools perfectly square and true, with no chipped or cracked edges. Cut tiles shall generally be positioned on the perimeters, and setting-out should be carefully carried out to ensure this. Tiles shall similarly be carefully and cleanly cut around pipes, fixings and other projecting components.

## 19.06 PROTECTION

The completed works or parts thereof shall be protected by the Contractor against any damage.The works shall be handed over in perfect condition. If any damage is incurred then the Contractor shall remove and/or replace the same at no additional costs. The Contractor shall exercise all care to protect the works executed by other trades and not covered by his Contract. Any damage to these shall be made good and the works restored at no additional cost.

## 19.07 MEASUREMENT AND PAYMENT

Wall tiling work covered under this section of Specifications, complete and approved, will be measured and paid for per square meter including preparations, rendered backing, tile adhesive, grouting and pointing etc. at the respective individual item rates entered in the Bill of Quantities and generally in accordance with the applicable terms and Conditions of theContract.

*** END OF SECTION ***

# SECTION - 20
# SUSPENDED CEILING

## 20.01 SCOPE OF WORK

The Work under this section of the Specifications consists of furnishing all plant, labor, equipment, appliances and materials and in performing all operations in connection with the installation of suspended ceilings at locations shown on the Drawings, complete in strict accordance with this section of the Specifications and applicable Drawings and subject to the terms and conditions of the Contract.

## 20.02 GENERAL

a. Suspended ceilings to be provided at the project shall be Gypsum Board Ceiling:

b. All the suspended ceilings shall be installed in conformance with British Code of Practice: CP 290.

c. In most cases, ceilings are intended to conceal or contain services. The Contractor shall liaise directly with the mechanical and electrical services specialists and following this shall prepare detailed reflected ceiling plans and shop drawings of each area of ceiling indicating the intended method of framing, tile layout, position of electrical light fittings & smoke detectors etc. for the approval of Engineer. Requirements for removable access panels shall be determined by the services specialists and indicated on the drawings accordingly. Suspended ceilings shall then be installed as per the approved shop drawings.

d. Suspended ceilings shall be installed by specialist subcontractors as per the recommendations of the manufacturers in conformity with the approved shop drawings and to the approval of the Engineer.

## 20.03 SAMPLES

a. The Contractor shall provide samples of gypsum board ceiling tiles, and proposedsuspension and framing systems for the selection and approval of the Engineer. The samples shall be in finished sizes and shape, the cost of which shall be deemed to be included in the rates. The approved samples shall be retained by the Engineer to formstandards against which deliveries will be judged.

b. All the materials shall be supplied from the approved manufacturers as per the samples approved by the Engineer.

## 20.04 MATERIALS AND INSTALLATION

### Gypsum Board Ceiling

Gypsum board ceiling shall comprise of gypsum board tiles, 12 mm thick, fixed to the framing.

Framework to be fabricated from wooden runners or galvanized steel metal frame. Sizes of sections to be appropriate to spans and framing conditions so that a perfectly stable and rigid result is achieved.

Boards are to be fixed to the framework with rustproof self-tapping screws/nails with heads countersunk and filled. Gaps between boards are to be filled with a suitable inert filler and thewhole surface sanded off so as to produce a perfectly plane smooth matching surface.

Removable access panels shall be provided where indicated on the approved reflected ceilingplans. The panels shall be secured by suitable rustproof proprietary fixing devices.

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**Propriety Acoustic Suspended Ceiling Systems**

The suspended ceiling systems shall be from approved suppliers/ manufacturers all propriety ceilings shall be inclusive of all suspension system steel framing, trims angles exposed or concealed grid system subject to approval of the Engineer.

Approved Manufacturers

- U.S. Gypsum
- Armstrong
- Or other approved suppliers, manufacturers

**Dampa Acoustic Metal Pan Ceiling Systems**

The suspended aluminum ceiling systems shall be from approved suppliers/ manufacturers all propriety ceilings shall be inclusive of all concealed/ exposed system as recommended by the manufacturers and approved by the Engineer. Various whole sizes and perforation patters in conformation with colored acoustic felt bonded to the reverse side of the tiles shall be used to achieve optimal acoustics. All panels must achieve NRC rating of 0.75 ASTM minimum panel size shall be 600mm x 600mm.

Approved Manufacturers

- Dampa U.K
- Thermec Engineering (PVT) LTD.
- Or other approved suppliers, manufacturers

- **Other Ceiling Systems**

  - Mineral fiber Acoustical Ceiling Tiles.
  - Glass fiber Insulation board adhesive applied to chip board panels
  - False Ceiling comprising of Fur Wood Planks.
  - False Ceiling of Fur Wood planks with deodar wood facia

## 20.05 WORKMANSHIP

a. The installation of suspended ceiling shall be carried out by approved specialist subcontractors with adequate experience in this field.
b. The Work shall generally by executed in accordance with best practice; members shall be cut, drilled and framed, joints made, fixings positioned and made, and work assembled and fixed generally in accordance with approved shop drawings and manufacturersrecommendations.
c. The workmanship shall generally comply with the standards set out in CP 290.
d. All suspended ceilings shall be set out and installed in accordance with the details shown on the approved reflected ceiling plans and shop drawings and no modification in form or detail may be made except with the specific approval of the Engineer.
e. All fixtures shall be fixed as per approved plans.
f. No suspended ceilings shall be fixed until all wet trades and services above have been completed.

## 20.06 PROTECTION

a. All the suspended ceilings shall be protected throughout the Contract period.
b. Any damage occurring to the suspended ceiling before the Contract completion from whatever cause shall be made good or replaced at Contractor's cost, all to the approval of the Engineer.

## 20.07 MEASUREMENT AND PAYMENT

Suspended ceilings shall be measured per square meter and paid at the unit rates entered in the Bill of Quantities inclusive of all framing, suspension system, accessories, painting, access panels, recesses for lights etc., complete in all respect.

*** END OF SECTION ***

# SECTION - 21
# EXTERNAL WALL CLADDING

## 21.01 SCOPE OF WORK

The Work covered under this subsection of Specifications consists of Supplying, providing and fixing of Sand blasted Thatta Stone, over all external surfaces where shown in drawings. The work will include all labour, tools, scaffolding, hoisting equipment, appliances and materials of every kind and character; and in performing all operations in connection with procurement, transportation and delivery, supply and installation/ fixing of Thatta Stone, complete in all possible respects, in strict accordance with requirements of applicable Drawings and Bill of Quantities as specified herein, and to the entire satisfaction of the Engineer and subject to the terms and conditions of the Contract.

## 21.02 APPLICABLE STANDARDS

- ASTM C1063 - Standard Specification for Installation of Lathing and Furring to receiveInterior and Exterior Portland Cement-Based Plaster.
- ASTM C1780 - Standard Practice for Installation Methods for Adhered Manufactured Stone Masonry Veneer.
- International Building Code Council ,IBC

## 21.03 MATERIAL

Thatta Stone Slab Cladding, Jang Shahi Stone or any other approved natural sandstone

## 21.04 EXECUTION / INSTALLATION

The installation of Thatta stone shall be carried out by approved specialist subcontractors withadequate experience in this field.

The Work shall generally by executed in accordance with best practice; stones shall be set and layered, joints made, fixings positioned and made, and work done generally in accordance with approved shop drawings and to the approval of the Engineer in charge and architect recommendations.

The subcontractors will prepare a mock-up, for Architects approval, before start of stone work and will prepare additional mock-ups, if required by Architect, until approved, as described below:

Mock-Up:

At location directed by Architect, install minimum 48 inch (1219 mm) long by 48 inch (1219 mm) high sample wall panel using specified stone, trim, accessories and substrate construction to show:

a. Substrate preparation.
b. Water resistant barriers.
c. Stone setting method.
d. Stone pattern, texture, and color range.
e. Mortar joint size, color, and profile.
f. Opening details.
g. Flashing.
h. Inside and outside corners.
i. Trim pieces.
j. Workmanship.

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Maintain approved mock-up during construction to establish required standard of workmanship, and basis of comparison for installation of stone work. Do not remove approved mock-up until directed by Architect.

a. Shape of stone to fit each other approximately. Knock off weak portions to bring stones toeven bearing.

b. The general pattern for sandstone veneer is to be 2 against 1, a few 3 against 1, and some 2 against 2. no 3 against 3 will be permitted.

c. No continuous horizontal joints to exceed 7 FT in length unless specifically requested

d. Provide vertical joints at 12 feet intervals. 20% of vertical joints may be angled.

e. Clip 60% of sandstone units on both ends for an average projection of 1‖ to 1-1/2‖ fromface of wall.

f. Cut stone at building corners to a straight vertical line from top to bottom of wall.

g. Grout the void between stone and backup with slush mortar as stone is laid.

h. Joints: 1/2 IN to 3/4 IN wide.

i. Provide both vertical and beveled head joints. Work all joints so that all joints are in thesame plane.

j. Provide 4‖ minimum overlap in coursing.

k. Completed stone work shall match accepted mock-up panel.

l. Do not use stone units with chips, voids, stains or other defects which might be visible inthe finished work.

m. Maintain pattern consistency throughout building.

## 21.05 BUILT-IN ITEMS:

a. **Steel Door Jambs:** Grout steel door jambs set in masonry full of mortar as wall is built.

b. **Flashings:** Ensure that flashings are in proper place before proceeding with stone work.

c. **Accessories:** Install weep holes, fabric flashing and other accessories in accordance with

**d. Control Joints:**

- Install vertical control joints at approximately 20 FT on center (or other spacing as indicated) and at column lines.
- Some latitude in spacing increases may be acceptable if approved by Architect and Owner.
- Relate joints to building design.
- Saw cut 1/8 IN joints after stone is laid

## 21.06 MEASUREMENT & PAYMENT

All work done under this section shall be measured per square meter and paid at the unit rates entered in the Bill of Quantities. Thickness tolerance will be measured to the nearest 1/2".

*** END OF SECTION ***

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# SECTION - 22
# WATER RETAINING STRUCTURES

## 22.01 SCOPE OF WORK

The Work covered under this subsection of Specifications consists of furnishing all labour, tools, scaffolding, hoisting equipment, appliances and materials of every kind and character; and in performing all operations in connection with procurement, transportation and delivery, supply and installation of special provisions for water retaining structures to ensure water tightness in all possible respects in strict accordance with requirements of Drawings and Bill of Quantities as specified herein, and to the entire satisfaction of the Engineer and subject to the terms and conditions of the Contract.

## 22.02 GENERAL

a. Special consideration shall be given to the control of cracking and the provision of dense impervious concrete. Special consideration will also be given to the design of the concrete mix and to the supervision of the placing and compacting in order to provide a dense impermeable concrete. The mix shall be of the stiffest consistency having a workability which will ensure that it can be satisfactorily placed in the formwork and compacted without risk of segregation, honey-combing, sweating or bleeding. Special care shall be given to the method and order of placing the concrete and to the construction of joints in order to achieve full continuity and complete water tightness.

b. The Contractor shall maintain an accurate record of ambient temperature at Site.

c. Ambient temperature shall be measured using mercury thermometers or other thermometers acceptable to the Engineer.

d. Throughout the concrete work, the Contractor shall employ full time on the Works suitable number of qualified and experienced Engineers whose sole duties shall be as follows;

- Design of concrete mixes
- Control of quality of concrete
- Supervision of mixing, transporting, placing, compacting, finishing, curing and protecting concrete including thermal control of concrete pours.
- Supervision of sampling and testing.
- Preparation and submission of test certificates and reports.
- Compilation and keeping of record.
- Such other duties as the Engineer may direct.

## 22.03 CEMENT CONTENT

The minimum cement content for all water retaining structures shall be 385 kg/m3 and the maximum cement content of 500 kg/m3. The maximum water-cement ratio shall not exceed 0.42.

## 22.04 ADMIXTURES

a. Suitable admixtures from BCR, Sika, Fosroc, Betocrete C-16or Master Builders may be used in concrete mixes with the prior approval of the Engineer. The amount of admixtures added to each batch of concrete requires careful control and shall be added in the doses as recommended by the manufacturers and approved by the Engineer. The cost of the admixtures shall be deemed to be included in the rates.

b. For use of an admixture, the information required by the Engineer shall be submitted to himfor each admixture for his approval.

## 22.05 JUNCTION OF FLOOR AND WALL

Where the walls are designed to be monolithic with the bottom slab and beam system, a continuous upstand section of the wall shall be cast at the same time integrally with slab. A suitable arrangement of the reinforcement and formwork shall be made to facilitate this. The height of this upstand, which shall not be less than specified shall be sufficient to enable the next lift of formwork to fit tightly and avoid leakage of the cement paste from the newly deposited concrete. Such leakage, where it occurs is liable to cause porosity in the finished concrete and isnot acceptable.

## 22.06 PIPES THROUGH WALLS AND FLOOR

When it is necessary for pipes to pass through a wall or bottom floor, it is preferable to cast the pipes into the panel when it is concreted. If this is not practicable, it will be necessary to box out. In either case, it is desirable that the position of the pipe shall not coincide with a joint. When an opening has been boxed out the sides of the opening shall be treated as construction joint.

All piping and fittings shall be tested as a unit for leaks immediately prior to concreting. The testing pressure above atmospheric pressure shall be fifty (50) percent in excess of the pressure to which the piping and fittings may be subjected but the minimum testing pressure shall be not less than 1.0 N/mm2 150 psi above atmospheric pressure. The pressure test shall be held for four hours with no drop in pressure except that which may be caused by air pressure.

No liquid, gas or vapour, except water not exceeding 32°C nor 0.135 N/mm2 pressure, is to be placed in the pipes until the concrete has thoroughly set.

The concrete cover of the pipes and fittings shall be not less than 1½ inch. The piping and fittingsshall be assembled by welding, brazing, solder seating, or other equally satisfactory method. Screw connections shall be prohibited. The piping shall be so fabricated and installed that it will not require any cutting, bending, or displacement of the reinforcement from its proper locations.

Drain pipes and other piping designed for pressure of not more than 1 psi above atmospheric pressure need not be tested.

## 22.07 ARRANGEMENT OF REINFORCEMENT

Particular attention shall be given to the spacing of reinforcement at points so that access to the concrete surface can be provided to enable it to be prepared to receive the following batch of concrete.

The length of lap and anchorage provided shall be in accordance with the requirements of ACI 318-95.

## 22.08 FORMWORK

Ties used to secure and align the formwork shall not pass completely through any part of the water retaining structure unless effective precaution can be taken to ensure water tightness after their removal. The ends of any embedded ties shall have cover equal to that required for the reinforcement. The gap left from the end of the tie to the face of the concrete shall effectively be sealed. Any steel left in the structure shall be adequately protected against corrosion.

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## 22.09 CONSTRUCTION

The degree of success in achieving a watertight structure depends on the quality of workmanship in making and placing concrete, good on site organization, proper ground water control, clean and dry excavation, careful storage of materials, close-fitting formwork, correctly fixed reinforcement and clean joints.

It is essential that the concrete, when placed, is thoroughly compacted to form a dense uniform mass. The mix shall be of adequate workability and compaction by vibration. Immediately after the removal of formwork, the concrete surface shall be carefully inspected and any defects madegood as soon as possible.

## 22.10 CURING

Even after minimum curing period specified in the clause pertaining to curing in the Specifications for Plain and Reinforced Concrete, it may be desirable to prevent drying of the concrete and to restrict the range of temperature changes which it is subjected to.

## 22.11 INSPECTION AND REPAIR

As soon as possible after completion of the water retaining structures, the structure shall be examined for defects which may lead to water penetration or leakage. All openings exposed to the weather shall be covered and all water on the floors shall be removed and the surfaces allowed to dry before the inspection. Water retaining structures shall be tested in accordance with BS: 5337 or other approved standard.

Defects that are revealed through which water may penetrate or leak shall be repaired by the Contractor to the entire satisfaction of the Engineer. Where internal repairs are to be made, the areas of weakness shall be isolated by suitable means and any cracks sealed by an approved process by a specialist contractor experienced in this type of work.

## 22.12 INSPECTION AND MAKING GOOD

### a. Inspection of Defects

(i) Surfaces exposed after stripping shall be inspected by the Concrete Engineer of the Contractor, together with the Engineer. The following standards shall be valid for the assessment of the concrete quality:

- The appearance of the concrete surface must conform to the specified classification of finish, refer to Subsection 3.04.2.
- The concrete surface must be uniformly smooth, even and free of ridges and other irregularities,
- The concrete must have a pore-free, dense surface on all sides with no evidence of segregation or inadequate compaction,
- No reinforcing bars may be exposed or signs be present, which indicate an inadequate concrete cover of the reinforcing bars,
- No hair cracks shall be visible.

(ii) During the inspection, the Engineer will determine the type and extent of defects to be eliminated and ascertain if cracks are still moving.

(iii) The Contractor is obligated, if necessary and applicable, undertake the following in accordance with para (iii) below:

- To expose reinforcing bars, which apparently have an inadequate concrete cover, in the area determined by the Engineer and to bend them inward through suitable measures.

- To caulk out honeycombs and similar defective spots, which are traceable to segregation of the concrete.

- To pressure-grout damaged areas, cracks, etc.,

- To seal all hair cracks of a measured width of more than 0.05 mm, with suitable and recognized epoxy resin material.

- To seal all holes resulting from the removal of formwork bolts and the like.

- To demolish and reconstruct such structural concrete members which cannot satisfactorily be repaired or which are otherwise unfit for the Works in the Engineer's opinion.

- To propose and apply a proven system or measures according to the type and extent of the defect, as set out in para (iii) below in order to achieve a result and appearance acceptable to the Engineer.

**b. Patching & Repair**

(i) Apply a cementitious repair material approved by the Engineer. The proprietary cementitious repair material, bonding agent and application method shall meet the following criteria:

- The repair material shall be cementitious and shall possess a similar thermal coefficient to the base concrete.
- The repair material shall have shrinkage compensating characteristics.
- The bonding agent shall be compatible with both the existing concrete and therepair material.
- The system shall exhibit long term durability.

The proprietary cementitious repair material and bonding agent shall be stored, applied and cured in accordance with the manufacturer‘s requirements and recommendations.

Finish the cementitious repair material to a straight line with the existing surface, to the profile of the original undamaged concrete section.

The Engineer may direct that where the cover to the existing reinforcing is insufficient, therepair may protrude beyond the existing concrete face. The protruding edges of the repair shall then have a 45° chamfer, and shall be horizontal or vertical to provide a pleasing finish.

The Engineer‘s evaluation of the Contractor‘s proposed materials and application methodshall be based on the above criteria.

The Contractor shall submit full details and specifications of his proposed materials and installation methods to the Engineer for approval prior to commencement of work.

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This shall include certificates of approval from competent authorities to prove theirsuitability.

(ii) Patching work shall begin at the latest 24 hours after stripping, however it shall in no case be undertaken prior to carrying out the joint inspection of the concrete by the Contractor and the Engineer.

(iii) Patching and repair work shall be executed only through qualified personnel using high quality and recognized materials, e.g., concrete and cement or special mortar. A special bonding agent such as suitable epoxy resin and the like, of first class quality shall be used where appropriate, to also ensure good bonding and adequate denseness in the joints.

(iv) All costs for repair and patching work are to be borne by the Contractor.

**c. Sealing of Cracks**

(i) Cracks detected in concrete members cast by the Contractor, are to be sealed according to the directives of the Engineer, provided cracked structural concrete members are not rejected by the Engineer.

(ii) All cracks identified by the Engineer as requiring remedial work shall be sealed by injection of epoxy resin to a maximum depth of 4‖ from the exposed surface. The surface of the cracks must be cleaned. Injection nipples are to be provided at6‖ to 12‖ intervals and the remaining surfaces of the cracks are to be sealed with a thixotropic epoxy resin compound. Prior to the injection, the crack shall be cleaned of dust etc. by blowing oil free and clean compressed air through all the injection nipples. In case of cracks in vertical or sloped walls, the injection must start at the lowest nipple.

(iii) The epoxy resin shall be Fosroc Nitokit TH System or product of equivalent or better performance and as approved by the Engineer. Epoxy injection shall be in accordance with the manufacturers written instructions. Note that on completion of injection and curing of the epoxy, the nipples are to be removed and the exposed surfaces ground or scraped smooth (following heating with a hot air gun) to provide a smooth, even and tidy finish restoring the original profile).

## 22.13 MEASUREMENT & PAYMENT

All work done under this section shall be paid under relevant respective works; i.e. concrete, reinforcement, formwork, waterproofing etc.

*** END OF SECTION ***

## SECTION - 23
## POLYVINYLCHLORIDE (P.V.C) WATER STOPPER AND SWELL BARS

### 23.01 SCOPE OF WORK

The work comprises of providing all labour, tools, equipments, to install, place and fabricate in position and locations rubber water stops together with all jointing and sealing materials as per recommendations, specifications of the Manufacturer and instructions. All embedment in concrete, lapping, turning, sealing shall ensure absolute water tightness subjected to any pressures. The workmanship and operation shall be perfect and guarantee leak proof at places wherever used in the structure.

### 23.02 MATERIAL REQUIREMENTS

Polyvinylchloride water stop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride (PVC). The compound shall contain such additional resins plasticizers stabilizers or other materials needed to ensure that when the material is compounded and extruded to the shapes and dimensions shown, it will have physical characteristic when tested by U.S. Corps of Engineers Test Method specified below:-

| Physical Characteristic | No. of Specimens Tested | Requirement | Test Method |
|---|---|---|---|
| Tensile strength using die III, not less than | 5 | 1750 psi | 568 |
| Ultimate elongation using die III, not less than | 5 | 350% | 573 |
| Low temperature brittleness, no sign of failure such as cracking or chipping at | 3 | (-) 35 F | 570 |
| Stiffness in flexure, 1/2‖ span, not less than | 3 | 400 psi | 571 |

**Swell Bar** is a flexible, hydrophilic water stop based on synthetic rubber, with cross-sectional dimensions of 20 mm by 10 mm, applied with the help of adhesive which is used to secure the swell bar to the concrete substrate and around penetrations.

Swell bars of approved make shall satisfy provisions of a Type B (structurally integral) protection as defined in BS 8102: 2009 to waterproof construction joints and penetrations in underground waterproof reinforced concrete structures.

### 23.03 CONSTRUCTION REQUIREMENTS

Splices in the continuity or at the intersections of runs of PVC water stoppers shall be performed by heat sealing the adjacent surfaces in accordance with the Manufacturer's recommendations or as directed.

A thermostatically controlled electric source of heat shall be used to make all splices. The correct temperature at which splices should be made will differ. With the material used but should be sufficient to melt but not char the plastic. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the water stoppers shall be used to reform the ribs at the splice. The continuity of the characteristic components of the cross section of the water stoppers design (ribs, tabular centre axis, protrusions, and the like) shall be maintained across the splice.

The expansion joints wherever indicated on drawings shall have centre bulb rubber water stops or its equivalent as indicated on drawings to be cast integrally with the in-situ-concrete of retaining walls, beams, columns, slabs or at any locations marked on the drawings incorporating junction places or as straight lengths with separate intersection pieces to be jointed at site as per Manufacturer's recommendations and Specifications. The water stops shall be installed so as tohold them securely in their correct position during the placement of concrete. The concrete shall be fully and properly compacted around the water stops to ensure that no voids or porous areas remain. Where reinforcement is present adequate clearance shall be left between water stoppers and the reinforcement to permit proper compaction of concrete. No holes shall be made through any water stops. Hot or cold volcanising for jointing places of water stoppers at site shall be done with the prior Approval in accordance with the Manufacturer's recommendations and specifications.

## 23.04 MEASUREMENT

Measurement will be made of the number of linear feet/meter of Polyvinylchloride water stoppersof the size and gauge shown on the drawings acceptably placed in the work. In computing the quantities, no allowance will be made for laps.

## 23.05 RATE AND PAYMENT

Payment will be made for the number of Linear feet/meter measured as provided above at the contract unit price per Ft/M. for Furnishing and installing polyvinylchloride water stoppers and shall include full compensation for splicing materials, splicing, sealant and all other work related to the section.

*** END OF SECTION ***

## SECTION 24

## WATERPROOFING OF BASEMENTS, TANKS AND BELOW-GRADE STRUCTURES

**24.01 SCOPE OF WORK**

The Work covered in this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with the supply and installation of waterproofing of basements, pools, tanks and below grade structures,complete in strict accordance with this section of the Specifications and the applicable Drawings, Bill of Quantities and subject to the terms and conditions of the Contract.

**24.02 GENERAL**

The Contractor shall be completely responsible for the supply and proper installation of the specified waterproof membrane system, or its equivalent, to make the basement structure absolutely watertight. All membrane material shall be new and shall comply with the specified material requirements. The Contractor shall produce testing certificates to verify that the membrane meets the specification and is suitable for the end use intended.

The Contractor shall engage a qualified waterproofing specialist as a sub-contractor to supply,install and protect the waterproof membrane system, all in accordance with the membrane manufacturer's recommendations. The waterproofing specialist shall be approved by the Engineer and shall be selected on the basis of past track record, technical reliability, capability and willingness to supply technical assistance, and reputation for standing behind his product and work. The Contractor shall submit the name of his Specialist Contractor at the time of tender.

All basement and below-grade structures (including lift pits, water tanks, fuel tanks, etc) shall be protected by a water proof membrane all round, of the type complying with clause 14.07.

The Contractor shall be responsible for the implementation and maintenance of a temporary dewatering system to keep the Site dry at all times for proper installation of the membrane system. Where relief holes and/or relief panels are required to be left in the basement structure to prevent hydro-static uplift during the construction stage, these shall be cast back with full water proofing treatment following completion of the superstructure and/or when directed by the Engineer.

**24.03 PERFORMANCE GUARANTEE**

The Contractor shall provide a ten (10) year guarantee for water tightness of the basement, swimming pools, tanks and/or other below-grade structures (including lift pits), effective from thedate of completion of the whole Works. The guarantee shall be submitted in the specified formatand shall be subject to the approval and acceptance by the Employer.

Should any leak, moist lines, points or patches occur during the guarantee period, the Contractorshall immediately carry out the necessary remedial works, to restore the water tightness of thestructure, at no cost to the Employer.

The Contractor shall make good damages to all finishes (such as plaster, paint, panelling, tiling,etc.) electrical or other installations, or other property, caused by water leakage or dampness. Alternatively, he shall reimburse the Employer for making good such damages.

**24.04 SHOP DRAWINGS**

The Contractor shall provide the Engineer with comprehensive shop drawings showing all details and procedures for the relevant parts of the Works. Reasonable time shall be allowed for checking by the Engineer in programming the production of shop drawings. Delays caused by the late submission of shop drawings or repeated amendments of drawings due to inadequate or inaccurate drawings will not be recognized as a reason for extension to the contract time.

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The manufacturer's standard application details shall be used only as a guide for the preparation of shop drawings. The Contractor is deemed to have taken due consideration of the particular requirements of this contract based on the tender documents. Where necessary, the Contractor is expected to improve upon the manufacturer's standard details to suit the project requirements and such amendments shall be shown in shop drawings for approval by the Engineer. The Contractor shall not be entitled to extra contract cost and/or time in this respect.

## 24.05 CONCRETE CONDITIONING

The membrane material shall be compatible with the surface of concrete. The use of curing compounds, release coatings on concrete forms, or admixtures in the concrete that interfere with the adhesion of the barrier material to concrete shall not be permitted.

Curing compounds shall not be used on concrete surfaces unless the Contractor can conduct field tests to demonstrate that complete removal of the compound can be achieved before application of the membrane. Alternatively, the Contractor may perform field tests to establish thecompatibility of the compound with the membrane materials and the concrete surface.

Release agents such as oil, wax, grease and silicone which transfer to the concrete surface during placement, and contribute to poor adhesion between membrane system and concrete, shall not be used. The use of proprietary paint systems applied to forms and formulated to prevent contamination of the concrete surface, or the use of polyethylene lined forms, may be considered.

Special purpose admixtures, such as water-immiscible chemicals intended to retard evaporation of water during cure, may create adhesion problems and shall not be used.

## 24.06 CONCRETE SURFACE PREPARATION

i. Surface defects, including tie holes, unless otherwise specified in the Contract Documents, shall be repaired immediately after form removal. All honeycombed and defective concrete areas shall be removed down to sound concrete which shall then be cleaned. If chipping is necessary, the edges shall be perpendicular to the surface or slightly undercut. No feather edges shall be permitted.

ii. Unless specifically recommended by the membrane material manufacturer, normal mix Portland cement-based patching materials shall not be used for the repair of small surface voids and rutted cracks on account of their relatively poor adhesion to cured concrete. Such repair shall be effected with suitable resin-based materials composed of the same resin found in the protective membrane material mixed with inert fillers, but the specific recommendation of the membrane system manufacturer shall be obtained before using such materials for patching. Coarse aggregate shall be omitted.

iii. Large surface voids and rutted cracks shall be dry packed with graded aggregate and pressure grouted with suitable non-shrink cementitious mortar.

iv. The quantity of mixing water shall be limited to that necessary for handling and placing. The patching material shall be thoroughly mixed to the extent that it is the stiffest consistency that will permit placing.

v. The area to be patched and a band at least 150mm wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. After surface water has evaporatedfrom the area to be patched, an approved bonding agent shall be well brushed into the prepared surface. The premixed patching mortar shall be thoroughly consolidated into place, struck off so as to leave the patch slightly higher than the surrounding surface andleft undisturbed for at least 1 hour to allow for some initial shrinkage before being finally finished. The patched area shall be kept damp for 7 days.

vi. Proprietary compounds may be used in lieu of, or in addition to, the foregoing patching procedures. Such compounds must be used strictly in accordance with the manufacturer's recommendations. Specific approval from the membrane manufacturer shall be obtained before proprietary compounds are used for patching. These materials shall be compatible with the membrane system and the concrete, and not interfere with good adhesion between the two.

vii. Fins, protrusions or similar irregularities projecting from the concrete surface shall be removed back to the surface by chipping, bush-hammering, needle-gunning, or wire brushing. Care shall be exercised to obtain a reasonably planar surface for application of the membrane

system. Sharp offsets in the surface, such as those caused by formwork misalignment, shall be mechanically abraded to provide gradual and smooth transitions between the offset surfaces.

viii. The Contractor shall employ a suitable method of repair to stop any seepage or flow of water into or through the concrete structure prior to application of the membrane system.The method of repair shall depend on the type of defects present in the concrete and thesource of water.

ix. Generally, surfaces shall be dry and must be newly exposed concrete, free of chemical contaminants and loose, weak or unsound materials.

## 24.07 MATERIAL

i. The waterproofing membrane shall be applied in double layers, each layer shall be a self-adhesive 2.0 mm thick water-proofing sheet membrane, ―Aquafin-Latex‖ or equivalent, consisting of a non-woven polyester, coated on both sides with an elastomeric bitumen compound. The upper surface of the membrane is covered with polyethylene film with 8 cm strip of siliconized release paper and the lower surface is fully covered with siliconizedrelease paper to protect the adhesive side of the rolls during storage and is removed just prior to application. Joining of seams shall be only by hot air welding without any use of adhesives or solvents. Proper accessories such as preformed corners, outlets, pipe collars and terminations shall be used. The waterproofing membrane shall conform to ASTM Standards D-146, D412 and D751.

ii. The 2.0mm thick waterproofing membrane shall have high biaxial strength, elongation and puncture resistance. It shall be resistant to most chemicals including all ground chemicals and be root-impenetrable. All joints shall be hot air welded with double seams with a testchannel for integrity verification.

iii. The waterproofing membrane shall be terminated at the top of vertical walls, pile caps, etc. by heat-welding to double anchor strips or mechanical fastening by using an adhesive underlay (Heat-seal or an approved equivalent). The adhesive underlay shall be capableof providing an excellent bond between the waterproofing membrane and substrate. Termination using only liquid-applied sealants is not acceptable.

iv. The water-proofing membrane for walls shall be covered with cement-sand mortar layer protected by block wall, as shown on the Drawings.

v. Prior to commencement of waterproofing treatment, the Contractor shall submit shop drawings for each waterproofing detail and endorsed by the manufacturer or his approved representative. These are to be approved by the Engineer. The shop drawing shall be on a CAD-recognizable format and A1 or AO size.

## 24.08 METHOD OF CONSTRUCTION

Generally, the application procedures shall be consistent with the Manufacturer's recommendations.

The procedure of work shall be as follows unless otherwise modified by the Engineer to suit thesite and project requirements.

a) At formation level, install proper drainage system including dewatering system, drain channels, sumps and pumps, to ensure dry site conditions. Lay stone soiling and concrete screed as specified. Concrete surface shall be smooth wood float finish.

b) The concrete surface shall be prepared in accordance with the requirements of the clause headed ―Concrete Surface Preparation‖ in this Specification. The surface shall be free ofsharp projections such as nail heads, concrete ribs, etc.

c) The waterproofing shall be a well-designed system installed by a single Specialist Waterproofing Contractor strictly according to the recommendations of the manufacturer.

d) The waterproofing membrane shall be identified with the manufacturer‘s inscriptions on the packaging.

e) The waterproofing membrane shall be rolled out lengthwise and aligned with an adjoining membrane to form an overlap joint of 50mm. A special hand operated hot-air welding gun or versions of the automatic welding machine shall then be used to fuse the membranestogether and weld the overlap.

f) If required, single anchor strips shall be welded to the waterproofing membrane bi-directionally to provide structural anchoring to the base slab and create watertight compartments at not more than 100 sq.m grid.

g) The waterproofing membrane may be terminated to pile caps, ground beams using double anchor strips or an adhesive underlay.

h) If an adhesive underlay is used for termination, the concrete surface shall be primed with an approved primer prior to the installation of the adhesive underlay. The waterproofing membrane shall be terminated by using an adhesive underlay to bond the membrane to the structure and thereafter mechanical fastening it. The minimum widths for the termination using adhesive underlay shall be 250mm at ground beams, pile caps. The membrane shall be terminated using the same termination methods.

i) The waterproofing membrane shall be terminated at the top of the vertical walls at least a 300mm minimum above ground level by only using double anchor strips.

j) For horizontal below ground areas, the waterproofing membrane shall be protected with a minimum 25mm thick 1:3 cement and sand screed render prior to the commencement of further construction activities.

k) For vertical surfaces, the waterproofing membrane shall be covered with the approved protection material prior to backfilling.

**24.09** **Membrane Flashing**

Flashing shall be provided at the line or joint where the membrane will terminate, particularly at the diaphragm walls and pile foundations. The flashing material used shall be of approved and durable type, and shall be resistant to weathering and mechanical damage. The flashing material shall be compatible with all other material employed in the membrane system and shall not cause chemical reactions when in contact with the latter.

The surface of adjoining building elements that are used to form the terminus of the waterproofing membrane shall meet the same requirements as the surfaces that receive the barrier. A treated timber nailer or equivalent device shall be used to mechanically secure the top edge of the flashing material according to the manufacturer's recommendations. Reglets shall not be used as a substitute for a nailing strip or device.

Flashing materials shall be the same as or compatible with those used in the waterproofing system. Compatibility shall be determined by the membrane manufacturer.

**24.10** **JOINTS**

The waterproofing specialist shall give careful consideration to the design of membrane details at expansion, contraction and construction joints in the concrete substrate to minimize damage to the membrane due to differential movement.

Where the movement of soil substrate supporting horizontal membrane is likely to occur, the waterproofing specialist in association with the Contractor shall take appropriate measures as necessary to ensure the integrity of the membrane is not compromised.

**24.11** **MEMBRANE PROTECTION**

Membrane protection shall be applied immediately following the application and testing of the waterproofing membrane. No membrane material shall be left permanently exposed for any period of time after installation.

The Contractor shall take immediate steps to cover up the Works following the application of membrane protection. If for any reason the Works cannot be covered up immediately, the Contractor shall be responsible for taking all necessary and approved measures required either to protect the membrane material from damage or if damage of the material has occurred, to make good all such damage, for the duration of exposure of the Works prior to covering up.

## 24.12 WATER TESTING

Water tightness test of below-grade holding structures shall be carried out in full compliance with BS 8007 Section 9, all at the Contractor's expense within contract period. Any leaks found shall be rectified at the Contractor's expense and re-tested to the Engineer's satisfaction.

Where required by the Engineer, water testing shall be carried out to check the performance of horizontal membrane applications. The area to be tested shall be flooded with at least 25mm ofwater. Drains shall be plugged and kerbings (temporary or permanent) shall be formed to retainthe water for a period of at least 24 hours. Any leaks found during this period shall be repaired in accordance with the manufacturer's recommendations and the area shall then be retested. Before repairing the surfaces, they shall be dry.

Where it is impractical to water test an area because the slope of the substrate would produce excessive water depths, the membrane shall be tested by allowing water to run continuously over the area for a period of at least 8 hours. During the 8 hour period, the whole area shall be kept completely immersed.

Where water testing is not possible because of job conditions, location, etc, a thorough inspection shall be carried out to check all laps, terminations and flashings for any evidence of 'fish mouths', incomplete adhesion or other conditions that may be detrimental to the watertight integrity of the membrane.

## 24.13 WATERPROOFING TO TANKS AND LIFT PITS

### Lift Pits and Non-Potable Water Tanks

a) All lift pits (bases and walls up to Ground Floor level) shall be constructed using waterproof concrete. The waterproofing shall be effected by incorporation of an approved waterproofing additive.
b) The internal faces of lift pits in contact with the ground and of concrete tanks holding non-potable water, including the underside of tank roofs, shall be made watertight with Industries or other approved equivalent.
c) Preparation of the concrete substrate and the method of application shall be carried out strictly in accordance with the manufacturer's directions. The substrate shall be well saturated with water but the concrete surface is to be kept matt damp and free of ponding before mortar application. The sealing mortar shall be applied in 3 coats of 1.0 - 1.5mm each. The preceding coat shall be allowed to set before applying the next coat but the timelapse between successive coatings shall not be more than 2 days. The total dry coat thickness of Tricolastic sealing mortar or equivalent (3 coats combined) shall not exceed 3mm.

### Potable Water Tanks

a) The waterproofing system provided to internal face of concrete tanks holding potable water for consumption shall be of a type which is non-toxic and approved for such use. Flexible waterproofing coating Flexolastic or approved equivalent shall be used for waterproofing of potable water tanks as per manufacturer's recommendation.
b) The Contractor shall allow for 9‖ wide central bulb water-stop for all walls installed in accordance with the earlier requirements of the Concrete Specification.

## 24.14 MEASUREMENT AND PAYMENT

The waterproofing of basement raft and walls shall be measured per square meter /feet and paid as per unit rates entered in the Bill of Quantities inclusive of all overlaps, complete in accordance with the terms and Conditions of Contract.

PVC water stopper/ swell bars shall be measured per running meter/ feet and paid at per unit rates entered in the Bill of Quantities of accepted lengths a complete with accordance with theterms and Conditions of the Contract.

*** END OF SECTION ***

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## SECTION – 25
## EXTERNAL PAVING, PARKING AREAS

### 25.01 SCOPE

The work covered under this section consist of providing and making items as per specifications laid down herein under, drawings and Bill of Quantities.

- Washed Terrazzo in Pavings / Walkways
- Concrete Roads / Parking Areas
- Split Tiles work in Pavings / Walkways as dividing Strips/Panels
- Split Tiles on External Steps

### 25.02 MATERIAL REQUIREMENTS

**Cement, Sand, Aggregate:** Shall conform to specifications given in the relevant Section of this specification.

**Concrete Blocks:** Shall conform to specifications given in the relevant Section of this specification.

**Tiles and Special Dry Bond Mortar:** Shall conform to specifications given in relevant Section of this specification.

**Concrete Pavers / Tuff Tiles / Uni-block:** As per manufacturer's specifications

**Chips:** For washed terrazzo shall conform to specifications given in relevant section of "Materials" & washed Terrazzo.

**Strength:** Min 28 days Cylinder Compressive strength for 50 mm thickness shall be 35 Mpa (5000 psi) and for 60 / 80 mm thickness, it shall be 48 MPa (7000 psi).

**Thickness of Sub Base and Pavers:** Recommended thickness of sub base and pavers isshown in Table below:

| Application | Thickness of sub-base mm (in.) | | Thickness of paver (mm) |
|---|---|---|---|
| | Dry Area | Low Wet Area | |
| **LIGHT DUTY** Residential, drive way, walk ways, parking patios etc. | 0 to 76 (0 to 3) | 100 to 204 (4 to 8) | 50 |
| **MEDIUM DUTY** Residential, Streets, Public Parking, service road, maintenance area, canal lining, storage area, City petrol pumps etc. | 100 to 152 (4 to 6) | 254 (10) | 60 |
| **HEAVY DUTY** City Streets, Loading deck Industrial floors, Highway petrol pumps etc. | 204 (8) | 305 (12) | 80 |

**Shapes:** Pavers are available in Uni-Block, I-Section, Rectangle, Half Rectangle, Wavy,Heagon and Delta Shapes

**Quantity and thickness:** Quantity and thickness required per Square meter of different shape and size of pavers is shown in Table below:

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**Specification for the Paving Stone**

| S.No | Type | Thickness (mm) | Area per Tile Sq cm (Sq In.) | Nos. of Tiles/Sqm (Tiles/Sq Ft) |
|---|---|---|---|---|
| 1. | Uni-Block | 50/60/80 | 249.74 (38.71) | 39.81 (3.70) |
| 2. | I-Section | 50/60 | 270.83 (41.98) | 36.90 (3.43) |
| 3. | Rectangle | 60/80 | 196.90 (30.52) | 50.67 (4.71) |
| 4. | Half Rectangle | 60 | 128.12 (19.86) | 78.01 (7.25) |
| 5. | Wavy | 60 | 275.99 (42.78) | 35.83 (3.33) |
| 6. | Hexagon | 60 | 346.64 (53.73) | 28.83 (2.68) |
| 7. | Delta | 50 | 245.74 (38.09) | 40.67 (3.78) |

## 25.03 CONSTRUCTION REQUIREMENTS

The entire area under external Pavings shall be prepared by dressing earth, to a hard or graded surface where necessary, the prepared surface shall be made up to the required levels by fillingand consolidating earth in accordance with the specifications for earth filling under floors.

**Washed Terrazzo**

3/4" Terrazzo in pigmented grey cement 1:2 shall be laid over 1-3/4‖ Plain Cement Concrete Class-C over 4‖ thick Plain Cement Concrete Class-E over 4‖ thick sand over compacted earthfor Pavings / Footpaths.

After the Terrazzo topping has hardened sufficiently to prevent dislodging of the marble chipping, but before the cement has acquired enough hardness so as to disable removal, the cement shall be washed away moving a wire brush and a steady flow of water from a flexible hose. Terrazzo Surface shall be washed carefully and sponged to expose grains.

**Split Tile Strips**

Washed Terrazzo in paving / walkway is divided into panels by providing and making strips or width indicated on the drawings with double glazed split tiles as specified hereunder.

The Tiles 9x1/2‖ x 2-1/4‖ x 3/8‖ shall be joint in 3/8‖ thick dry Bond Mortar and laid over 1-3/8‖ thick plain cement concrete Class-C over 4‖ thick Plain Cement Concrete Class-E overcompacted earth.

**Parking Areas / Roads**

Uni-Block tuff pavers or Concrete pavers, as specified in drawings, shall be installed over Parking Areas and Roads, the area under the paves shall be prepared to the required levelsby compacting the earth to at least 95% modified AASHO max dry density, the compacted earth shall be tested and approved before the layer of sand is placed. The prepared sub-grade shallthen be covered over by 6‖ of sand cushion compacted over which the specified pavers shall be laid closely packed tamped in place and filled with sand.

**Finish on External Steps**

Granite Slabs of approved shade and color shall be fixed to the external stair steps of RCC with special Dry bond mortar over ¾‖ thick Cement Sand base plaster (1:2).

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## 25.04 CURING

All work involving cement shall be cured thoroughly for at least 3 days.

## 25.05 MEASUREMENT AND PAYMENT

Measurement for all the items covered under this section shall be made in Sq. ft/m of the actual surfaces completed and approved.

The rate quote from the work items covered in this Section shall constitute full compensationfor all materials, labour equipment, plant and all incidentals to complete the works.

*** END OF SECTION ***

# SECTION 26
# DEMOLITION OF EXISTING STRUCTURES / RCC WORK

## 26.01 SCOPE OF WORK

This Section specifies the labor, materials, equipment, and incidentals required for the demolition, relocation, and/or disposal of all structures, walks, concrete slabs, retaining walls, trees and bushes, and including foundation, walls, columns, floors, piers, partitions, boundary walls, stoops and any other structures to the level of the demolition grade; to be removed as shown on the Drawings, as directed by the Engineer incharge in writing due to any defect / damage / reconstruction and as specified herein.

Site clearance will consist of the removal, disposal of demolition material; filling of all excavations to the existing ground elevation; and the grading and smoothing of the site.

## 26.02 METHOD

The Contractor shall examine the various Drawings, visit the site, determine the extent of the Work, the extent of work affected therein, and all conditions under which he is required to perform the various operations.

All demolition work will done under the inspection of Engineer in charge. Contractor shall notify the Engineer incharge in writing prior to beginning any demolition work.

When the work of demolition is substantially complete, the Contractor shall again notify the Engineer incharge that the work will be ready for final inspection.

Before commencing demolition work, all structure relocation, bypassing, capping, and/or modifications necessary will be completed. Actual work will not begin until the Engineer incharge has inspected and approved the prerequisite work and authorized commencement ofthe demolition work.

Demolition operations shall be conducted in such a way as to minimize damage by falling debris or other causes to adjacent buildings, structures, roadways, other facilities, and persons. Interior and exterior shoring, bracing, or support to prevent movement or settlement or collapseof structures to be demolished and adjacent facilities to remain, shall be provided by the contractor, if needed, or if directed by the engineer in charge, at his own cost.

The Contractor shall be responsible for all damage to private or public property as a result of his fault or negligence in connection with the prosecution of the work and shall be responsible for the proper care and protection of all work performed until completion and final acceptance.

Arrangements shall be made with the Police Department to prohibit parking of vehicles in the near vicinity of the actual demolition.

In order to prevent the blowing of dust and dirt, the Contractor will be required to wet down andkeep wet the structures before and during wrecking operations, all rubbish and debris stockpiled on the site, and all rubbish or debris is being loaded for disposal. All obstructions shall be adequately barricaded and lighted at night.

The Contractor shall comply with applicable laws and ordinances governing the disposal of materials, debris, rubbish and trash off or on the project area; and shall commit no trespass onany private property in the disposal of the materials without permission of the property ownersinvolved.

No explosives shall be used at any time during the demolition. No burning of combustible material will be allowed.

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The Contractor shall fill and compact all voids left by the removal of pipe, structures, etc. with materials described herein to a grade that will provide for positive drainage of the disturbed area to drain run-off in direction consistent with the surrounding area. The Contractor shall provide all fill materials to the site as needed. Compaction of fill shall match the compaction of adjacent undisturbed material.

Once the demolition is started, it shall be continued until completed.

Contractor shall notify utility companies or local authorities furnishing gas, water, electrical, telephone, or sewer service to remove any equipment in the structures to be demolished and to remove, disconnect, cap, or plug their services to facilitate demolition.

## 26.03 DISPOSAL OF MATERIAL

All salvageable or useable material or equipment and other products of the demolition, to be retained by the Engineer, as indicated in writing by the engineer in charge, shall be moved to a designated area by Contractor for later use. The Contractor shall promptly remove all other materials from the site as instructed.

All material, equipment, rubble, debris, and other products of the demolition not retained by the Engineer shall become the property of the Contractor for his disposal, off-site, in accordance with all applicable laws and ordinances at the Contractor's expense. The sale of salvageable materials by the Contractor shall only be conducted off-site.

The proper transport and disposal of all material shall remain the responsibility of the Contractor. On-site storage of items is prohibited.

## 26.04 MEASUREMENT AND PAYMENT

Measurement for payment for demolition work will be done in similar units in which these itemswere paid, if constructed. No additional payment will be made for pumping or other difficulties encountered due to water.

The rate shall include cost of all such operations mentioned above including necessary labour, materials, transport, scaffolding, stacking the serviceable materials, disposing the unserviceable materials within the lead specified, all as directed by the Engineer-in-charge.

***** END OF SECTION*****

# SECTION 27
# SOLING

## 27.01 SCOPE OF WORK

The work to be done under this section of specifications consists of furnishing all plant, labour, equipment, appliances, materials and performance of all operations required in connection with the construction of stone or gravel bottoming under foundations and/or floors in strict accordance with the specifications and Drawings and/or as directed by the Engineer. The scope of this section of specifications is covered with detailed specifications as laid down herein.

## 27.02 MATERIAL

Stone/ Gravel

Stone to be used shall comprise of strong, hard, durable stone of the specified/approved size, free from impurities, quarry sap, dust, dirt and solubility characteristics. The stone/ gravel shall be obtained from approved quarries and shall be sound, free from laminations and weak cleavages.

## 27.03 CONSTRUCTION

### *I.* Preparation of Sub-grade

Sub-grade shall be formed of suitable materials free of clods, roots, stumps, bush or other objectionable material.

Sub-grade material shall be placed in successive layers not exceeding 6 inch. (150mm) in thickness loose measure, and each layer shall be thoroughly compacted to give the specified density.

The sub-grade will be compacted at optimum moisture content and loose pockets, if any, cut-out and refilled with selected materials in layers not more than 6 inch. (150mm) thick and formed to levels and grades shown on the Drawings.

Compaction shall be done by approved methods consistent with the soil/material to be compacted.

The maximum dry weight density of the sub-grade shall not be less than 95% of Modified AASHTO requirements.

Maximum density is defined as the maximum dry weight density as determined by ASTM Designation D-1557 (MOD-AASHTO).

### *II.* *Stone Soling*

The stone shall be well graded having a maximum size or 2 inch (50mm). It should be graded down to 3/4 inch (20mm).

The soling material shall be laid and packed to even grades and well rolled to a consolidated thickness as shown on the Drawings.

The whole of the surface of the compacted stone bottoming will be blinded with or any other approved gritty material, after the interstices have been filled with smaller size stones, so as to effectively fill in the voids and crevices, watered, if necessary and again thoroughly rolled with the same roller to produce a smooth and even surface free from irregularities, true to line and level.

Care is to be taken to avoid any damage to existing structures, mains or pipes while rolling operation is in progress. In places inaccessible for a roller, compaction shall be done by hand tampers weighing not less than 9 kg or power rammers as directed by the Engineer.

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## 27.04 MEASUREMENT AND PAYMENT

Soling shall be measured per cubic ft/ Meter; on areas and in thickness as shown on the Drawings and paid for at the unit rates entered in the Bill of Quantities, inclusive of compaction, grading, leveling, bracing, shoring etc.

*** END OF SECTION***

# SECTION 28
# COLOR CRETE

## 28.01 SCOPE OF WORK

The work to be done under this section of specifications consists of furnishing all plant, labour, equipment, appliances, materials and performance of all operations required in connection with the supply, batching, mixing, placing, finishing and curing etc of Color-Crete in strict accordance with the specifications and Drawings and/or as directed by the Engineer. The scope of this section of specifications is covered with detailed specifications as laid down herein.

## 28.02 MATERIAL

Color-Crete is a concentrated color admixture, available in powder, granular, or liquid form. COLOR-CRETE is designed to be used in all cementitious materials, producing a wide variety of color effects in architectural concrete.

Since it is a mix-in, integral colorant, which means the color is permanent for the life of the concrete, added to concrete. Color-Crete integral color transforms plain concrete into a workable artistic material that can match or highlight any theme or decor.

It can be supplied in powder, liquid and granular form from approved supplier / manufactures. Colorcrete shall conform to ASTM C-979 standards requirements.

## 28.03 APPLICATIONS

- Base color for stamped concrete
- Manufactured concrete pavers
- Tilt-up panels, pre-cast concrete
- Cast-in-place slabs on grade
- Cast stone and roof tiles
- Stucco, plaster
- Flooring

Stamped, broomed, troweled, sand-blasted and exposed aggregate are several finishing techniques that can transform the look of color-crete concrete.

## 28.04 BATCHING & MIXING

Use a minimum cement content of 470 pounds per cubic yard. Cement substitutes, such as Flyash or slag, should not be used unless supplier is consulted for suggestions. If a cement substitute is used, it must be added to all mixes on the project having the same color. Do not exceed a 5″slump (.45 water to cement ratio).

Ideally, when mixing at the plant, load the color with the head water then add the balance of the load. Make sure mixer is not dry.

Make sure mixer is empty and no concrete left from previous batch, backspin if necessary. Mix the drum or mixer for a minimum of 75 revolutions at mixing speed and a minimum of 5 minutes. When color is added at the job site, increase mix time to 8 to 12 minutes.

Always check concrete for thorough and complete color dispersion before placing. Be sure to use the same mix design and slump (4″) from truck to truck (If higher slump is required it may be obtained by the use of water reducing admixtures).

It is important to use the same cement as different cements can have different shades of gray that can affect the color. Watch the slump closely as varying slumps is an indication of varying water to cement ratios and this can affect the final color. Never add Color-Crete to an empty drum/mixer.

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## 28.05 PLACING FINISHING AND CURING

Place all color-conditioned concrete on a thoroughly uniform compacted surface. Surface should be lightly dampened (no puddles). Concrete must be placed with consistent slump not exceeding 5″ maximum.

Troweling may begin after bleed water evaporates. Concrete should be stiff or plastic before troweling or brooming. Hard or late troweling will cause burns or dark spots. Do not add water or other foreign materials to surface upon finishing or discoloration will occur. For exterior installations, apply rotary, broom or other uniformly textured finish for both appearance and slipresistance.

Broom, rotary and rough finishes will usually cure more even-colored than smooth troweled surfaces.

Evaporation of water can cause a white hazy film (Efflorescence) on the surface of concrete. Efflorescence is more noticeable on colored concrete surfaces giving the appearance of a chalky or faded look. This effect can be reduced or eliminated by proper curing and protection against water penetration. Efflorescence can be removed with mild acid cleaners formulated to remove efflorescence. Manufacturer instructions should be followed and a small area shall be tested first to insure product will not discolor or etch the surface.

Use mechanical float or trowel if possible. The one-way motion of the blade creates a more uniform colored surface than the back and forth motion used in hand finishing. Move edgers inone direction only to produce a more uniform color.

Once the surface will support foot traffic, cure and seals products should be applied as recommended by the supplier, and as approved by the engineer. These products meet the ASTM Standards C309 andC1315.

When applying curing compounds use only those recommended and approved by supplier. Until it is completely cured, the color of concrete is normally less uniform and sometimes darkerthan the final color. Allow 28 days for full cure.

Do not place any foreign materials such as burlap, water, plastic, wood or paper on surface during the curing process. Contact with foreign materials during curing will cause discoloration.Do not water cure integrally colored concrete.

Do not apply cure and seal products in high heat, direct sunlight or windy conditions. Technical information for the appropriate cure product, limitations, precautions and application specifications should be followed.

## 28.06 LIMITATIONS

Variations in cement color, type and brand can all produce variations in the final color. Variations in aggregates, finishes, forming materials and methods as well as curing can all affect the final color. It is very important to keep all materials, operations and techniques as consistent as possible. Calcium Chloride should not be added to any concrete containing Color-Crete as it can cause discoloration in the finished product.

## 28.07 VERTICAL CONCRETE

Prior to pouring you should cast a jobsite sample. Whenever using new forms, they should be seasoned with a slurry of matching color, as required by the supplier.

All holes, plugs, gaps and joints should be patched or filled to prevent water leaking out in theseareas. If this is not performed the water to cement ratio in the area near the leaks will change and discolor the surface.

If using internal vibrators be careful not to allow the vibrator head to come in contact with reinforcing steel or the face of the form as this can create a dark spot on the surface known asa vibrator burn.

If using form liners, be sure to remove any cement paste from previous pours and to clean prior to each pour. When pouring integrally colored concrete always use a non-staining form release agent. To help achieve more color consistency, all forms should be stripped when concrete is of same age.

## 28.08 MAINTENANCE

Integrally colored concrete can be maintained by sweeping. Spills should be cleaned up as they occur. Dirt may be rinsed with clean water. Heavily soiled areas may be scrubbed with water and a stiff bristle brush. For stubborn stains use of WD-40 or other approved grease/ stain removers.

For the maintenance of large areas, auto scrubbers may be used. To maintain surfaces that have been sealed with acrylic sealers please refer to the Tech/Datasheets for the particular sealers used.

## 28.09 PAYMENT

Colorcrete rate shall include cost of all materials, storage required and shall be the approved rate as defined in the Bill of Quantities

*** END OF SECTION***

# SECTION 29
# EPOXY POLYURETHANE RESIN FLOORING

## 29.01 SCOPE OF WORK:

The Work covered in this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the substrate/ surface preparation, laying, leveling finishing of Epoxy/ Resin flooring and/or Epoxy/Resin wall finishes complete in all respect with strict accordance with BOQ, in patterns, color and designs as shown in the applicable Drawings and as the approval of Engineer Incharge

## 29.02 MATERIAL:

All materials used in the slip resistance, epoxy floor system shall be manufactured and provided by a single manufacturer to ensure compatibility and proper bonding. The Contractor will use adequate numbers of skilled workmen thoroughly trained and experienced in the necessary crafts and completely familiar with the specified requirements and methods needed for proper performance of the work

### Physical Properties

| *Property* | *Standard* | *Requirement* |
|---|---|---|
| Compressive strength | BS63 19 | 50 N/mm2 |
| Flexural strength | BS631 9 | 34 N/mm2 |
| Tensile strength | BS631 9 | 16 N/mm2 |
| Abrasion resistance | Fed. Spec. 141A | 97 mg weight loss 0.03 mm depth of wear |
| Impact resistance | BS 8204 Part 1 | 0.2 mm indentation |

### Electrical Properties

| *Property* | *Standard* | *Requirement* |
|---|---|---|
| Surface resistance | BS 2050 | 5x104D to 1 x106D |
| Charge Decay | Fed test method 101 B, method 4046 | 5000V to zero in less than 0.1 seconds |

### List of Approved Vendor/Make

BASF, CIPY, FOSROC, SIKA, PIDILITE or any other approved equivalent.

## 29.03 SUBMITTALS

Before start of work the Contractor will submit the following for the approval of engineer.

a. ***Product Data:*** Submit manufacturer's product data sheets on each product and system to be used including;

- Preparation instructions and recommendations.
- Storage and handling requirements. 3. Installation methods.
- Maintenance requirements.

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b. **Selection Samples:** For each system specified, provide two sets of samples and colorcharts, representing manufacturer's full range of colors and patterns.

## 29.04 DELIVERY, STORAGE & HANDLING

***Delivery:*** Materials shall be delivered to the job site in sealed, undamaged containers. Each container shall be clearly marked with manufacturer's label showing type of material, color, and lot number.

**Storage:** Store all materials in a clean, dry place with a temperature range in accordance with manufacturer's instructions.

**Handling:** Handle products carefully to avoid damage to the containers. Read all labels and Material Safety Data Sheets prior to use.

Proper Storage and handling of the material is the sole responsibility of the Contractor. Any damaged material due to improper storage or handling will be replaced by the Contractor at hisown cost.

## 29.05 APPLICATION:

Epoxy flooring is usually applied in the following steps

### 29.05.01 Examination

- Inspect all surfaces to receive epoxy flooring. Verify that surfaces are dry, clean, and free of contaminates that would prevent epoxy flooring from properly adhering to the surface.
- Conduct calcium chloride testing according to ASTM F1869.
- Conduct surface profile inspection according to ICRI Technical Guideline No.03732.
- If any unsatisfactory conditions has been found; report in writing to the Engineer for its rectification before starting work.

### 29.05.02 Surface Preparation:

- Prepare surfaces using methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- If required, create a surface profile by sand blasting or mechanically abrading the surface.
- Clean Surfaces thoroughly prior to installation. It is essential that surface should be sound, clean and dry surfaces in order that maximum bond strength is achieved between the substrate and the flooring system. All dust and debris should be removed prior to application of the product.
- All cracks, crevices and undulations shall be filled with manufacturer's recommended flexible epoxy filler mortar/ material.
- .Repair any non-moving surface deviations with manufacturer's recommended patching material.

### 29.05.03 General points for Coating Applications:

- Install coatings in accordance with manufacturer's instructions.
- Mix multi-component materials in accordance with manufacturer's instructions.
- Use application equipment, tools, and techniques in accordance withmanufacturer's instructions.
- Uniformly apply coatings at spread rates and in number of coats to achieve specified mil thickness recommended by the manufacturer.

- Mark any indicators/ levels/ signs, if required, as shown on the contract drawingsand according to manufacturer's instructions.
- Key in all drains, edges, and transition points according to manufacturer'sinstructions.
- Broadcast aggregates in accordance with the specified system and manufacturer's instructions.
- Adhere to all limitations, instructions, and cautions for epoxy coating as stated inthe manufacturer's published literature.

29.05.04 **Primer application:**

Primer coat on the naked surface as a bonding coat and proper drying time should be given to carry out the Epoxy Flooring

29.05.05 **Epoxy Underlay**

Generally material is supplied in pre-weighed packs (base and hardener & aggregate), which are ready for immediate on-site use. Part mixing of these components is not acceptable and will affect both performance and appearance of the finished floor. Mixing should be carried out using either a forced action mixer, ora heavy duty, slow-speed drill with proprietary mixing paddle attachment. The components should be mixed in a suitably sized mixing vessel.

The base component should be added to the mixing vessel first and followed by the hardener and these two components mixed together for approximately 2 minutes until an even colour and texture is obtained.

Thereafter, the contents of the graded aggregate pack should be slowly added and mixing carried out for a further 3 minutes until a completely homogenous material is obtained.

29.05.06 **Application of EPU**

**Mixing**
Epoxy polyurethane coating is supplied in pre-weighed packs ready to use on site. Solvent or thinners should not be added. A forced action mixer with a paddle fitted into a heavy duty, slow speed electric hand drill is recommended for mixing. Hardener component is mixed with Base resin in a suitable mixing vessel. The full colour paste is then added and mixed until an even colour is obtained.

Finally the filler as supplied is added and mixed further for three minutes until homogenous lump free slurry is obtained.

**Laying**
The material is poured onto the primed substrate and spread to the required thickness with a steel trowel. Alternatively, a serrated trowel can be used. The resinfloor should not be overworked but spread slowly and evenly. Immediately after spreading, the floor should be firmly rolled with a spiked roller to help release any entrapped air in the material and level any slight trowel marks. The floor should nowself- smooth to an even coloured dense, impervious floor.

The Contractor shall verify coatings and other materials are applied as specified and as shown in the construction drawings. He will verify coverages of the system as work progresses. Areas found not to meet the required thickness shall receive additional material until specified thickness is attained.

Manufacturer's representative shall provide technical assistance and guidance for surface preparation and application of coating systems.

The sequence of operation is similar to as described below for the Anti-Static flooring system except for earthing.

## 29.05.07 ANTI STATIC (CONDUCTIVE) FLOORING SYSTEM

Laying of anti-static (conductive) flooring system generally consists of following steps Surface Preparation, Primer, Antistatic Under-Coat, and Antistatic Top Coat. Moisture insensitive system is an optional only if the moisture content of the floor concrete is greater than 5.

### SEQUENCE OF OPERATION

*a.* **Moisture Testing**
Before the application of epoxy toppings, the concrete substrate shall be checked for moisture content with a Thermo-Hygrometer. For every 500 m2, aminimum of 5 readings should be taken to assess the average moisture content in the substrate. Holes of 16-mm diameter should be drilled to a depth of 50 mm, with a drilling machine. Immediately a slotted sleeve with a cap is to be inserted. 24 hours later, the cap should be removed and the hygrometer's probe should be inserted in the hole and left in place for 1 hour. The meter is than attached to the probe to take the reading. Epoxy topping shall be taken up only if the RH is 75 or lower (5% Moisture content & below)

*b.* **Surface Preparation**
Surface shall be attended by Mechanical abrasion method by using Standard equipment. Dust and loose particles shall be cleaned using vacuum cleaners. Neither water wash nor acid etching should be used for cleaning.

*c.* **Primer Application**
The primer shall be solvent free, mixed mechanically using a slow speed heavyduty drilling machine (400 to 500 rpm) fitted with a suitable paddle to achieve homogeneous mix, and shall be applied on the prepared surface. The primer shall be applied in a thin continuous film using a stiff brush or roller over dry surface. Over-application and puddles should be avoided. Primer will act as akey factor for adhesion between the concrete and Epoxy / Polyurethane topping.

*d.* **Putty Application**
Putty shall be applied to fill the micro crevices. Putty shall be mixed and applied using metal float manually to the entire surface and after 24 hrs. Buffing machine shall be used to minimize undulation followed by vacuum cleaning.

*e.* ***Earthing***
Charge dissipation is the measure of a floor's ability to provide static electricitywith a passage to ground potential. This can also be done by coupling the Conductive flooring with self-adhesive copper tape @ 600mmx600mm grid, tothe earthing point in the Epoxy POLYURETHANE system as shown below.

*f.* **Application of Undercoat**
This provides a conductive passage to earth. Thus strict adherence to coverage rate is critical.

*g.* ***Application of Topcoat / Seal Coat***
The material shall be mixed to achieve a uniform homogenous mix is obtained and spread on the substrate using a notched trowel. The spread material should be rolled firmly using a spiked roller to remove entrapped air and then allowed to set for at least 18 hours

*h.* ***Curing***
Epoxy Coating System materials shall be cured in compliance with manufacturer's directions, taking care to prevent contamination during stages of the application and prior to completion of the curing process. Temporary protection shall be applied by the contractor, until floor is fully cured as approved by the Engineer.

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## 29.06 PROTECTION AND CLEAN-UP

The following steps are to be taken for the protection and durability of floor.

a. Caution Boards shall be displayed after completion of the work

b. Installation areas must be kept free from traffic and other trades during the application procedure and cure time. Light foot traffic can will be allowed only after 24 hours of finishing the floor. It can be subjected to regular traffic only after 7 days of finishing the treatment, by which time it will have fully cured.

c. Protect adjacent surfaces not scheduled to receive the flooring by masking, or by other means, to maintain these surfaces free of the flooring material.

d. Provide adequate ventilation and fire protection at all mixing and placing operations. Prohibit smoking or use of spark or flame producing devices within 50 feet of any mixing or placing operation.

e. Provide polyethylene or rubber gloves or protective creams for all workmen engaged in applying products containing epoxy. No food allowed in areas of mixing or installation.

f. Protect finished surfaces of coating system from damage during construction.

g. Heavy objects or objects with protrusions shall not be dragged on the treated floor surface.

h. All trolleys moving on the floor shall have polyurethane wheels, which will not damage the floor system. Trolleys with MS or CI wheels shall not be used.

i. Hydraulic jacks having metallic pads shall be placed over rubber pads, during operation, to avoid any damage to the floor

j. Touch-up, repair or replace damaged flooring system after completion. Any damage or indentation caused to the floor by objects falling on the floor shall be repaired suitably, as per guidelines from manufacturer at contractor own cost.

k. Clean area and remove all debris upon completion of work.

l. Dispose of empty containers properly according to current regulations.

## 29.07 MAINTENANCE

Contractor shall provide maintenance and cleaning instructions for the floor system upon completion of work. It is the Owner responsibility to clean and maintain the surfaces to maintain manufacturer's warranty.

## 29.08 WARRANTY

The Contractor will provide a written warranty from the manufacturer against defects of materials for a period of 3 (three) years minimum.

## 29.09 MEASUREMENT AND PAYMENT

Measurement for all the items covered under this section shall be made in Sq. ft/m of the actual surfaces completed and approved

**Rate**

The rate shall include the cost of all labour and materials involved in all the above operations (including surface preparation) described above.

***** END OF SECTION*****

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# SECTION 30
# BRICK MASONRY

## 30.01 SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labor, equipment, appliances and materials and performing all operations in connection with furnishing and installing brick masonry, in foundation, super structure, Facia drains manholes and elsewhere as shown on the drawings in position; including Portland cement and sand for mortar & masonry, complete in strict accordance with this section of the specifications and applicable drawings and subject to the terms and conditions of the Contract.

The brick work wherever referred to shall be first class brick work. Unless otherwise specified the work shall be carried out in English bond or as shown on drawings.

## 30.02 MATERIALS

a. Portland cement for mortar shall conform to the applicable requirements specified in the section "Plain and Reinforced Concrete".
b. Sand for mortar shall be furnished by the Contractor and shall conform to the applicable requirements for sand specified in the section "Plain and Reinforced Concrete".
c. Water used in the manufacture of bricks and in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, alkali, salts and other impurities, and will be tested and approved by the Engineer.

### 30.02.1 MORTAR

a. Mortar for first class brick masonry, except where otherwise directed by the Engineer, shall be the ratio of cement (ordinary Portland Cement) Sand mortar asspecified in the BOQ and as per drawings. Ratio will be by volume and sufficient water to should be added to produce proper consistency for the intended use.

b. Where directed by the Engineer for increased workability, hydrated lime putty, approved by the Engineer, shall be added to the mortar but shall not exceed 25 percent, by volume of the dry cement.

c. Methods and equipment used for mixing mortar be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of water to the mix shall be rejected. Retempering of mortarshall not be allowed.

d. Cement and sand shall be thoroughly mixed in dry state on a pacca platform or on metallic sheets or trough water shall be added in sufficient quantity to make the mortar workable. Water shall be added in a manner so that segregation of cement does not take place. Mixing of mortar shall produce a homogenous workable mass.

e. Precautions:

- Only such quantity of mortar shall be prepared as can be used before the initial setting time of cement.
- Any mortar which has initially set shall not be used.
- At the close of day's work the mixing trough pans or platforms shall be thoroughly washed and cleaned.
- Accurately control and maintain specified proportions.

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### 30.02.2 BRICKS

a. All bricks, except otherwise specified, shall be of first class quality made from good brick earth, free from saline deposit and shall be hand molded. They shall be thoroughly burnt without being vitrified, shall be regular, uniform in shape and sizewith sharp and square edges, parallel faces and of deep red or copper color. Firstclass bricks shall be homogeneous in texture and shall emit a clear ringing sound when struck, and shall be free from flaws, cracks, chips, stones and modules of lime. First class brick in an oven dried condition shall not absorb more than 1/5 of its weight of water when immersed one hour in water at 21 to 27 degrees centigrade and shall show no signs of efflorescence on subsequent drying. The average compressive strength of five representative first class bricks shall be not less than 2000 psi and not less than 1500 psi for any individual brick.

b. All bricks shall be manufactured by the Trench Kiln Method or other standard methods approved by the Engineer. The earth used in manufacturing bricks shall be carefully selected and shall be free from objectionable quantities of lime, gravel coarse sand, roots, or other organic matter. Salts shall not exceed 0.3 percent and calcium carbonate shall not exceed 2.0 percent.

c. The moulds used in the manufacture of bricks shall be thoroughly sanded before each use and shall be sufficiently larger than the size of the bricks being manufactured to allow for shrinkage in drying and burning. Over-size, irregular and worn moulds shall be destroyed. Each finished brick for brick masonry shall be 9 inch by 4-1/2 inch by 3 inch in size and shall weigh between 3.2 to 4.2 kilograms. All bricks shall have a "frog" 1/4 inch deep on one face.

d. Samples of the bricks shall be submitted to the Engineer with test reports for his approval. Bricks of approved samples shall only be used in the works. If at any time, during the progress of the work, use of sub-standard material is found by the Engineer, such work shall be rejected and the Contractor shall replace the rejected work at his cost.

### 30.03 PLACING

a. The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the brick nor the use of mixed mortar. Brick shall not be placed duringrains sufficiently heavy or prolonged to wash the mortar from the brick.

b. Mortar already spread which becomes diluted by rain shall be remove and replaced before continuing with the work. All brick to be used in brick masonry shall be moistened with water for three to four hours before they are used by a method which will ensure that each brick is thoroughly and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brick masonry.

c. Bricks shall be laid "frog" upward with mortar joints and in English and Flemish bond as shown on the Drawings or as directed by the Engineer. Both bed and vertical joints shall be 1/4 inch in thickness completely filled with cement mortar as specified herein, and each brick shall be bedded by firmly tapping with the handle of the trowel.

d. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. Excess mortar at the outer edges shall be removed and joints drawn straight with the edge of a trowel and a straight edge. All anchors and similar work required to be embedded in the brick masonry shall be installed as the work progresses. At the completion of the work all holes or defective mortar joints shall be cut out and re-pointed.

e. Where shown on the drawing the exterior faces of the walls shall be finished by striking the joints as the work proceeds. The joints shall be struck by raking the green mortar after the brick work has been laid and finishing the joint with a pointing tool. Horizontal

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joints shall be struck to form a weathered joint and vertical joints shall be struck with a V notch. Care shall be taken that the striking tools do not develop a cutting edge as the object of striking the joint is to compress the mortar into the joints.

f. The exposed faces of all brick masonry shall be thoroughly cleaned and left bear with struck joints as specified above.

## 30.04 CURING AND REPAIR

a. All brick masonry shall be water cured and shall be kept wet for at least ten days by an approved method, which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements of the Specifications for water used in the manufacture of bricks.

b. If, after the completion of any brick masonry work, the brick is not in alignment or level, or does not conform to the lines and levels shown on the Drawings, or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer grants permission, in writing, to patch or replace the defective area.

## 30.05 SCAFFOLDING

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding shall be sound and strong with supports and member sufficiently strong so as to with stand all loads likely to come upon them.

Scaffolding which is unsafe in the opinion of the Engineer shall not be used until it has been strengthened and made safe for use of workmen. Cost of scaffolding etc., shall be included by the Contractor in the unit rate for masonry items.

Damage to masonry from scaffolding or from any other cause shall be repaired by the Contractor at his own cost.

## 30.06 TOLERANCES

All brick work shall be erected plumb and true to line and level with maximum variation in any storey height or any length of wall being one mm in one meter. The maximum tolerance in the length, height or width of any single masonry unit shall be ± 1/8 inch.

## 30.07 DAMP PROOF COURSE

### 30.07.1 In walls - Horizontal Application

All damp proof course unless otherwise specified shall consist of class 'C' cement concrete 2 inch thick shall be laid at required levels as per drawings and instructions of the Engineer. The D.P.C shall be tamped, consolidated, leveled and edges and corners made to the requirements of the relevant drawings including finishing and curing complete. After the DPC has dried apply two coat of bitumen 10/20 grade @ 20 lb. / 100 sq.ft.

### 30.07.2 In walls - Vertical Application

A damp proof course shall be applied if shown on the drawings, on wall below plinth shall consist of cement sand plaster (1:6) ¾‖ thick shall be applied on walls below plinth on interior and exterior faces as shown in the drawings or as directed by the Engineer. After a curing period of 3 days, hot bitumen 10/20 grade be applied on dried surface of mortar @ 20 lb./100 sq.ft. in two coats.

### 30.07.3 Under Floors

A damp proof course if shown on the drawings shall be applied under the floors in the same way as specified under walls-horizontal application.

## 30.08 CONSTRUCTION REQUIREMENTS

### 30.08.1 Precautions

Erect no masonry when the ambient temperature is 40 degree centigrade or less except by permission. Build upon no frozen work and lay no masonry having a firm of frost on their surfaces.

Should cuts be required in walls for the passage of conduit etc. the entire cut out shall be filled with mortar.

### 30.08.2 Selection of Bricks

The bricks shall be selected for face work before incorporating in the work. The brick for the face work in particular shall be of uniform size shape even colour and smooth texture. No extra payment shall be made for such selection of bricks or extra fair face work unless otherwise provided in the BOQ.

### 30.08.3 Soakage of Bricks

Before use all bricks shall be soaked in clean water in a tank for at least two hours.

### 30.08.4 Bond

Unless otherwise specified all bricks shall be laid in English bond with frogs upward.

### 30.08.5 Tools

All equipment used for mixing mortar, transporting it and for laying bricks shall be clean an free from set mortar, dirt, or other injurious foreign substances. It, shall be thoroughly cleaned, at the end of each day's work.

### 30.08.6 Progress

Brick work shall be carried up in a uniform manner. No portion shall be raised more than 3 feet above another at the same time. Temporary spaces left during construction shall be stepped and not toothed. Straight edges supplied to brick layer shall have courses marked on them with saw cut or measuring rod shall be provided and layer of courses shall be checked all over the building from time to time so as tohelp all courses level.

### 30.08.7 Fixtures

Holdfasts and similar fixtures shall be built in which in surrounding brick work in their correct position in specified mortar they shall be built in as the work progress and not inserted later on into space left for them.

### 30.08.8 Laying of Bricks

Each brick shall be set with both bed and vertical joints properly filled with mortar and thoroughly bedded. Thickness of joints shall not be less than 1/4" (6 mm) and shall not more than 1/2" (12 mm). The height of 4 courses and 3 joints as laid shall not exceed 1‖ (25 mm) in height of 4 bricks piled dry one upon the other.

No half bricks or bats shall be used except where necessary to complete the bends etc. At corners alternate courses of bricks shall be laid header wise and stretcher wise, so as to bind the two walls together. All brick work shall be truly plumbed and each set of four brick courses shall be checked with plumbed and straight edges. The joints of brick work which is to be pointed or plastered shall be raked out to a depth of half and inch (12 mm). The raking shall be done before the mortar sets each day. All anchors, ties and reinforcing shall be placed where required. Unless otherwise specified or shown on drawings metal ties in cavity walls / brick facing shall be spaced in a staggered manner with a minimum spacing of 3 feet horizontally and 18 inches vertically.

### 30.08.9 Anchors

Install reinforcing bars anchors projecting into the masonry a minimum of 6‖ and into the facing brick a minimum of 3‖ bars during the construction at 18‖ centers vertically and 36‖ horizontally.

## 30.09 BRICK WORK IN ARCHES

All the bricks used in arches must be selected carefully. The joints of all the bricks in each course shall be laid radially and bricks shall be cut to ensure uniformity in the width of the joints

### 27.09.1 Workmanship

Arches shall be constructed true to radius on rigid centering with 1/8‖ variation permitted. The centering shall be accurately constructed of wood preferably, or metal, depending on the radius of the arch. However, if masonry centering is used, the top shall be covered with building paper to permit masonry to move as the mortar shrinks.

### 27.09.2 Method of Construction

Arches shall be constructed in segments day be day as required by construction drawings, Brick work adjoining the arches shall be built level with the arch construction, so that the arch is not under load at any stage of construction.

Where arches are reinforced, the grount shall be poured, in stages as each segment is built. Grout must be kept clean of loose mortar, and of mortar projections at all times.

The construction of inverted arches if required shall require special effort to ensure that the stretcher bricks are cut to a true radius in order to provide a proper bed for the arch. The following procedure may be followed:-

a. Erect a wood frame, flush with the outer face of a wall, upon which the radius centre may be marked.

b. Nail a radius rod to this point which has been marked as extrados and intrados of the arch with allowance for 1/2" mortar joints.

c. As the work progresses up, the bricks intersecting the line of the extrados should be laid temporarily in position, marked and accurately cut to fit the radius.

d. After laying about eight course of brick in this manner the arch itself may be started using the radius rod to check the real points and the curve.

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27.09.3 Cut Brick Work

Bricks shall be cut dressed or grooved as required or shown on the drawings. No extra payment shall be made for such work.

27.09.4 Bed Plates of Concrete

Bed plates of cement concrete Class-C shall be provided under each beam or joints. They shall conform to the dimensions given in the drawings. The payments of bed plates will be made as per relevant BOQ item of cement concrete Class-C.

## 30.10 PROTECTION

All brick work shall be protected during construction from the effect of rain and frost or any natural forces. If the work already carried out gets damaged shall be made good by the Contractor at his own cost without any extra payment whatsoever.

## 30.11 MEASUREMENT AND PAYMENT

Measurement for payment for brick work will be made to the neat lines of the structures as shown on the Drawings or as modified for the appropriate items for which such brick work is incorporated. Deductions will be made for all openings for doors, windows, ventilators, gates etc.

Payment for brick work will be made at the unit rate per Cubic feet/ meter or as tendered in the Bill of Quantities. The unit rates tendered for such work shall include the cost of brick, mortar and all operations of erections, placing, curing, etc. Where necessary and of all other operations, procedures and requirements necessary to complete the brick work in accordance with this Specifications. Rate shall also include anchors, ties and reinforcing wherever used.

*** END OF SECTION***

# PLUMBING WORKS

## BASIC REQUIREMENTS

### 1.01 GENERAL:

This section includes the following basic mechanical requirements, which apply & complement Division 22 sections. The provisions of the contract including Drawings, General & Special Condition of Contract apply to this section.

The Specifications & Drawings make reference to certain Standard Specifications and also to certain manufacturers and equipment model numbers. The object of these references is to ensure that the equipment and materials offered by the Tenderers and supplied by the Contractor are in accordance with the required standard of quality, workmanship and capacities, etc. The object is not to limit the selection of equipment to a particular manufacturer unless specifically mentioned in the tender documents that a particular equipment and/or material is to be supplied.

It is clarified that the equipment and the materials complying with various standards, and of manufacturers other than mentioned in the tender documents shall be acceptable provided they meet the required capacities as specified and meet the intent of the specifications regarding quality and workmanship.

In case there is any deviation between any item or material offered by the Contractor from the tender specifications and drawings, the Contractor shall clearly draw attention to all such deviations and no such item or material shall be supplied by the Contractor without prior written approval of the Engineer Incharge.

These Specifications and accompanying Drawings are to be considered as supplementing each other and as such are intended to serve jointly as the basis upon which the Contractor shall establish a Contract Price, and upon which he shall base the performanceof the required work.

It is the intent of these Specifications and Drawings to call for finished work, tested, complete, and ready for operation.

These Drawings and Specifications are presented to the Contractor with the understanding that he is an expert and is competent in the preparation of Contact Bid.

Prices on the basis of information such as is contained in these documents, which do not include assurance as to their complete accuracy and validity, in all details, and which may depend, for proper execution, upon interpretation by the Engineer Incharge and other Authorities, during the course of construction.

For the above reasons, the Contractor shall understand that his submission of an unqualified proposal commits him to perform all work expressed and implied in the Drawings and Specifications without additional compensation. He shall further understand that such submission commits him without extra compensation, and within the scope ofthe Contract, to the following:

i. To provide, if required by the Engineer, the items or arrangements of greater quantity, better quality, or higher cost in the event that a disagreement with regard to; such items occurs between the drawings and specifications, or within one.

ii. To provide any small items of work not specifically called for, but required to complete the intended installations.

iii. To co-ordinate his work or adjust the same so that conflicts in space do not occurwith other trades involved at the project.

iv. To co-ordinate his work or adjust the same to suit site or any other existing conditions.

## 1.02 INTERPRETATION OF THE DRAWINGS & SPECIFICATIONS:

a. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instructions to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

b. It shall be understood that the specifications and drawings are complimentary and are to be taken together for a complete interpretation of the work. Exceptions are that notes on the drawings, which refer to an individual element of work, take precedence over the specifications where they conflict with the same.

c. No exclusions from, or limitation, in the language used in the Drawings or Specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are omitted.

d. The necessary Drawings utilise symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations. The work shall be installed in accordance with the diagrammatic intent expressed on the mechanical drawings, and in conformity with the dimensions indicated on final Architectural and Structural working Drawings and on equipment shop drawings.

e. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.

f. Certain details appear on the Drawings which are specific with regard to the dimensions and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field co-ordination for the indicated work.

g. Information as to the general construction not evident in this specifications and drawings shall be derived from structural & architectural drawings and specifications.

## 1.03 CODES, PERMITS & INSPECTION:

a. All works shall meet or exceed the latest requirements of all authorities exercising jurisdiction over construction work at the project site.

b. All required permits and inspection certificates shall be obtained, paid for, and made available at the time of completion of the Works.

c. All work shall be carried out in accordance with the following codes:

- Gujranwala Development Authority Building Bylaws
- NFPA Standards
- Uniform Plumbing Code

## 1.04 SHOP DRAWINGS BY THE CONTRACTOR:

a. All shop drawings shall be prepared on computer using current version of AUTOCAD software.

b. Prior to commencement of works on site and at least 3 weeks in advance of the drawing being required for actual execution, the Contractor shall submit to the Engineer Incharge 3 sets of hard-copy drawings plus soft-copy on AUTOCAD CD showing all major holes, cavities, embedded frames and other parts of the plant to be embedded in the floor, ceiling and walls, channels in the floors, cable trenches, cement pipes or other major conduits, which are needed for the successful and timely completion of the works. The Engineer Incharge after ascertaining the accuracy of these drawings, shall return 1 (one) set of the drawings to the Contractor, within 14 days of the receipt of these drawings.

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c. The Engineer Incharge shall review the drawings & (i) approve the drawing or, (ii) disapprove the drawings with comments or, (iii) disapprove the drawings with comments for rectification/revision. In the event of (iii), the Contractor shall correct/revise the drawing & resubmit 3 hard-copies of the drawings plus soft-copy on AUTOCAD CD to the Engineer Incharge for Approval. On a drawing being approved, the Contractor shall submit 6 hard-copies plus soft-copy on AUTOCAD CD for formal approval and distribution to relevant offices.

d. All drawings shall show plans and sections with sufficient details to clearly reflect the installation of the plant. All material specifications shall be provided on the drawings. All information required for preparing suitable foundation, for providing suitable access to the plant, for making openings in building structure, for co-ordination with electrical, plumbing, air-conditioning and other designs etc., shall be clearly provided.

e. Installation shall not be allowed to commence unless approved shop drawings are in possession of the Contractor, for which purpose shop drawings shall be submitted by the Contractor to the Engineer Incharge sufficiently in advance of actual requirementsto allow for ample time to the Engineer Incharge in checking and approval and no claim for extension of the Contract time will be considered by reason of the Contractor‘s failure to submit the drawings on time.

f. Each shop drawing submitted by the Contractor shall include a certificate by the Contractor that all related conditions on site relevant to the particular installation have been checked and that no conflict exists.

g. Any expenses resulting from an error mistake or omission in or delay in delivery of the drawings & information mentioned in sub-clause (b) of this clause shall be borne by the Contractor.

h. Approved Drawings approved shall not be departed from except on the instructions of the Engineer Incharge.

i. The approval by the Engineer Incharge for any submitted data, working drawings, performance curves, test certificates for any items, arrangements and/or layout shall not relieve the Contractor for many responsibility regarding the performance of the Contract. Such approval shall also not relieve the Contractor from responsibility ofany error in the submitted data & workings, brought to light at any time subsequentto any approvals.

## 1.05 VERIFICATION OF ACTUAL DIMENSIONS ON SITE:

The Contractor shall be solely responsible for verification of actual site dimensions and building layout. Building layouts shown on Construction drawings shall not be considered to be final with regard to dimensions and layout but shall be subject to actual verification by the Contractor. All working drawings prepared by the Contractor shall incorporate actual measurements taken on site. The Contractor shall ensure that all equipment can be conveniently fitted into the space allocated for this purpose.

If any space allocated for a certain equipment or combination of equipment‘s is insufficient or deficient in terms of clearances required for maintenance etc., the Contractor shall forthwith inform the Engineer Incharge of the discrepancy. He shall provide all reasonable assistance to the Engineer Incharge for verification of the same and for taking remedial measures. It is understood that all tenderers during tendering shall have checked that the equipment proposed to be supplied by them fits conveniently into the space allocated for this purpose. In case any such space is insufficient, the tenderer shall so indicate the deficiency in his tender documents and specify the space requirements. Failure on the part of the tenderer to point out any discrepancies existing in this regard shall make him liable, if his tender has been accepted, to bear the full consequences developing out of a certain equipment not fitting into a certain space allocated for the purpose.

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If any time during the progress of the Works any error shall appear or arise in the position, levels, dimensions or alignment of any part of the works, the Contractor on being required to do so by the Engineer Incharge shall at his own expense rectify such error to the satisfaction of the Engineer Incharge unless such error is based on incorrect data suppliedin writing by the Engineer Incharge, in which case the expense of rectifying the same shall be borne by the Employer.

The checking of any setting out or of any line or level by the Engineer Incharge shall not in any way relieve the Contractor of his responsibility for correctness thereof and the Contractor shall carefully protect and preserve all bench marks, site rails, pegs and other things used in setting out the Works.

## 1.06 RESPONSIBILITY FOR ACCURACY OF INFORMATION:

a. The Contractor shall be fully responsible for accuracy of all information necessary for successful and timely completion of the works.

b. The Contractor shall be responsible to make all measurements and set out all the necessary dimensions for their correctness.

c. The Contractor shall be fully responsible for ascertaining the accuracy of the dimensions and other information given in the tender documents before carrying out the work. The Contractor shall provide the complementary dimensions and communicate the same to the Engineer Incharge.

d. The Contractor shall consult the drawings and documents which have been prepared for the Civil and other contracts, which can affect his work and which are either kept on site or are available with the Engineer Incharge.

e. It shall be the responsibility of the Contractor to acquire all necessary information and ascertain its accuracy for co-ordination of the works with the works of other Contractors.

## 1.07 APPROVAL FOR MATERIAL & EQUIPMENT:

a. General: All equipment and material to be used in the Works shall be subject to approval obtained prior to delivery of the same on site. It is to be specifically noted that any approval given by the Engineer Incharge shall not relieve this Contractor of his obligations under this Contract.

b. Approval of Imported Equipment: For approval of all equipment, the Contractor shall be required to submit, within two weeks of the signing of the Contract, detailed submittals stating the equipment proposed to be supplied and providing supporting literature/brochures etc., to enable the Engineer Incharge to check conformance to the specifications. Performance curves and charts shall be submitted with the operating points clearly marked. All equipment submittals shall be accompanied with a certificate stating that the equipment proposed to be supplied fits into the space allocated for it with sufficient clearance around it to allow for installation of related ducting, piping, etc., and provides for maintenance clearances as required by the manufacturer of the equipment, and that all special requirements of the equipment have been accounted for.

c. Any additional information, test reports etc., required by the Engineer Incharge shall be furnished by the Contractor. All work related to the equipment shall only be commenced after receipt of written approval from the Engineer Incharge.

d. Approval of Locally Manufactured Equipment: The procedure of approval of locally manufactured equipment shall be the same as stipulated above for imported equipment. Additionally all locally manufactured equipment shall be inspected at the manufacturer's premises by the Engineer Incharge, and approval given prior to delivery on site.

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e. Approval of Imported Material: All imported material to be used in the works shall be submitted to the Engineer Incharge and approval obtained. Manufacturer's literature/brochure etc. that provide complete information on the material specifications, to enable the Engineer Incharge to check conformance to specification, shall be submitted. Any additional information, test reports etc., required by the Engineer Incharge shall be supplied by the Contractor.

f. Approval of Locally Procured Material: All locally procured material shall be submitted to the Engineer Incharge for approval, and approval obtained prior to delivery of the same on site. The procedure for obtaining approval shall generally be the same as given above for imported material, except that where manufacturer s literature is not available, a sample of the material shall be submitted along with type written notes indicating relevant source data and specs on the material. Any other samples, information, test reports etc., required by the Engineer Incharge shall be submitted.

## 1.08 STORAGE ARRANGEMENTS:

a) The Contractor shall make adequate arrangements for the storage of the materials arranged by him or supplied by the Employer. No payment shall be made to the Contractor for storage arrangements whatsoever. However adequate space for stores shall be provided on site to the Contractor.

b) The location of the store area shall be within the Site premises and/or selected with the consultation and approval of the Engineer Incharge.

## 1.09 MEASURING INSTRUMENTS:

The Contractor shall acquire and maintain on site various required measuring instruments in perfect working condition to enable the Engineer Incharge to check the quality and standard of all material and performance of equipment's.

## 1.10 STANDARDS & TYPICAL DESIGN:

The specification either cites or implies American, Pakistani or BS Standards where the context so refers. Other comparable United States, European or Japanese standards and typical designs are equally acceptable providing that they in no way detract from the quality, safety, operability or durability of the equipment and material furnished. However, when other standards or typical designs than those cited or implied are offered by the Contractor, he shall set forth in his proposal the alternate standards and/or designs he proposes so that a direct comparison can be made by the Engineer Incharge before the issue of a Letter of Award. Each specific difference from the specifications shall be clearly spelled out by the tenderer. If no alternates are set forth by the Contractor in his proposal, it will be assumed that the equipment and material will be in accordance with the standards and Where differences or contradictions appear between any of the laws, standards, codes, specified herein, the decision of the Engineer Incharge shall be final and binding on the Contractor and he shall not claim any additional charges for carrying out the same.

## 1.11 OPERATING & MAINTENANCE INSTRUCTIONS:

a. Bound Instructions: Five complete sets of operating and maintenance manuals, duly approved by the Engineer Incharge, shall be supplied by the Contractor, prior to handing over of the project to the Employer. Each set shall be permanently bound and shall have a printed hard cover. Each manual shall be inscribed with suitable legend for proper identification and use of the manual. The matter shall be legibly typed and/or shall be clear

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Photostat copies of the original documents, catalogues, photographs of site and equipment's, etc., including complete set of as installed drawings.

b. Fly sheets shall be placed before instructions covering each subject. The instruction sheet shall be approximately 8.5" by 11", with large sheets of drawings folded in.

c. Framed Instructions: Approved piping, wiring and control diagrams showing the complete layout of the entire system, including equipment, piping, valves and control sequence, framed under glass or in approved laminated plastic, shall be posted; where directed. In addition, condensed operating instructions, explaining preventive and procedures of safely starting and stopping the system shall be prepared in typed form, framed as specified above and posted beside the diagrams. Proposed diagrams, instructions and other sheets shall be submitted for approval prior to the posting. The framed instructions shall be posted before acceptance testing of the system.

d. Field Instructions: During the two months of the operation and maintenance period upon completion of the work the services of one or more project engineers shall be provided by the Contractor to instruct the representative of the Employer in the operation and maintenance of the Works. The field instructions shall cover all theitems contained in the bound instructions.

## 1.12 AS BUILT DRAWINGS:

The Contractor shall maintain an accurate record of changes as work progresses on a set of Construction Drawings supplied for this purpose, by the Engineer Incharge. He will keep these Drawings at the Site Office, and adopt the following procedure:

a. Make records in a neat and legibly printed manner with a non-smudging medium.

b. Identify each As Built Drawing as the ¯Project Record Copy‖, maintain Drawings in good condition, do not use them for construction purposes, and make them readily available to the Engineer Incharge.

c. Maintain As Built Drawings in a state current to the project. Failure to comply with this requirement may prejudice Progress Payments. The Engineers Incharge visual inspection shall constitute proof that As Built Drawings are current.

d. The Contractor on the completion of the Contract shall submit to the Employer through the Engineer Incharge one complete set of As Built Drawings (six prints of each drawing and one set of soft-copies of all drawings on AUTOCAD CD) showing Work as actually constructed.

## 1.13 MECHANICAL INSTALLATIONS:

Sequence, coordinate, and integrate the various elements of mechanical systems, materials and equipment. Comply with the following requirements:

a. Coordinate mechanical systems, equipment and materials installation with other building components

b. Verify all dimensions by field measurements.

c. Arrange for chases, slots and openings in other building components during progress of construction, to allow for mechanical installations.

d. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

e. Sequence, coordinate and integrate installations of mechanical, materials and equipment for

efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing the building.

f. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible.

g. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Provide required connection for each service.

h. Install systems, materials and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer Incharge.

i. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

j. Install plumbing equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

k. Install access panel or doors where units are concealed behind finished surfaces.

l. Install systems, materials and equipment giving right of-way priority to systems required to be installed at a specified slope.

m. Provide fire stopping materials in all annular spaces surrounding piping, conduits, ducts, etc. that penetrate fire-resistive construction.

## 1.14 DELIVERY OF EQUIPMENT / MATERIAL ON SITE

No plant or Contractor‘s Equipment shall be shipped or delivered to the Site until an intimation in writing has been applied for and obtained by the Contractor from the Engineer Incharge that the items may be delivered. The Contractor shall be responsible for the reception on Site of all Items, plant and Contractor‘s Equipment delivered for the purpose of the Contract.

Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-and damage and prevent entrance of dirt, debris and moisture.

Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor. Also protect flanges, fittings and piping specialties from moisture and dirt.

## 1.15 UNLOADING & STORAGE AT SITE

a. The Contractor shall unload all owner supplied or otherwise equipment & material at the site from delivery vehicles as the case may be. Items for permanent installation shall be properly stored in areas designated by the Engineer Incharge and shall be protected as required to prevent damage or deterioration of any type. Storage methods shall be such as to cause minimum inconvenience to others and shall be arranged to facilitate inspection.

b. All equipment and material storage shall be subject to the approval of the Engineer Incharge.

c. Items stored shall be blocked up at least six (6) inches off the ground.

d. The ends of all nozzles, pipes, tubes and conduits while in storage at the site shall be covered with a tube cap to save against entrance of rain water, blowing dirt, and otherforeign matter. Tubing shall be shipped and stored in neat bundles.

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e. Miscellaneous steel, plate work, pipes, etc. shall be protected by a prime coat of paint and kept painted throughout the storage and erection period to inhibit rusting unless such items are galvanised or have other corrosion proof finish.

f. All packing boxes, shipping containers, planking, covering, etc., shall become the property of the Employer as soon as the equipment and material which is contained therein arrives at the site. The Employer, on application from the Contractor, may permit the Contractor to use some of the boxes, containers, etc., without charge forequipment and material storage purposes.

## 1.16 QUALIFICATION OF EQUIPMENT & MATERIAL MANUFACTURER

a. All minor equipment and all materials shall be manufactured by companies which have had at least five years previous experience in the design and manufacture of equipment and or material of comparable type, capacity and operating conditions.

b. Where the requirements of this clause make any material non-obtainable the Employer and/or Engineer Incharge reserves the right to waive any portion or portions of it as required to obtain the intent of the Specifications.

c. When manufacturer's product is specified by name or equivalent, it shall be the sole judgment of the Engineer Incharge to determine the acceptability of any product which is offered as an equal to that specified.

d. Proposals shall be based on the equipment and materials specified, and any request to substitute any time shall be so mentioned in the proposal and the amount to be added or deducted shall be given. Any request for substitution after the date of Letter of award shall likewise be accompanied with the difference in price.

e. If the Contractor in his tender proposal has offered more than one source of equipment or material the selection of the source shall be at the judgment of the Engineer Incharge.

## 1.17 SAFETY PROGRAM

a. The Contractor shall strictly follow at his own cost the Safety Programme outlined below and such additional measures as the Engineer Incharge may determine to be reasonably necessary.

   i. Prior to commencement of work the successful Contractor shall submit safety programme for discussion with the Employer and the Engineer Incharge.

   ii. The Contractor shall prepare a plan of the Works' Site to assure that storage areas for materials and equipment are located on the project/work site for maximum efficiency. This plan will be subject to the approval of the Engineer Incharge.

   iii. Activities between different operations and different crafts will be coordinated.

   iv. The Contractor shall lay out and provide an efficient access system with information and directional signs posted as necessary.

   v. All employees will be instructed on safe work method.

   vi. The Contractor shall advise all his supervisory staff of their responsibility for the prevention of injury to persons or damage to property or equipment in their respective areas of supervision.

   vii. Safety will be included in all job planning. This will include providing safe construction equipment and vehicles, protective equipment necessary for protection of workmen, and establishing methods for safe operation.

   viii. Good housekeeping will be maintained at all times.

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ix. Scaffolds, ladders, ramp‖, runways etc. will be constructed properly and maintained in safe conditions.

x. Ample fire protection will be provided and fire hazards guarded, by the Contractor.

xi. Adequate lighting, ventilation etc. will be provided as necessary, by the Contractor.

xii. Equipment will be properly and regularly inspected and maintained by the

xiii. Contractor to the satisfaction of the Engineer Incharge.

xiv. The Contractor will assign to his employees only such duties as are within their physical and mental capabilities.

xv. The Contractor will hold monthly meetings with his supervisory staff and the man in charge at the lower level will hold safety meetings of 10 to 15 minutes with his crew each week.

xvi. First Aid facilities will be provided at job sites, the services of doctors and hospitals made available, and all supervisors instructed in handling of injured employees.

xvii. Adequate toilet facilities will be provided, maintained in a hygienic condition and their use enforced by the Contractor.

b. Accident reports will be furnished to the Engineer Incharge for onward transmissionto the Employer within 2 days of the reported accident.

c. Copies of the safety programme will be supplied by the Contractor to the Engineer Incharge and will be promptly posted in all offices in use of projects/works under this Contract.

d. At all construction sites the following instructions shall be followed:

i. Availability of safety (hard) hats, which should be worn by anyone visiting or working within the designated work area

ii. Controlled entry to the designated work area

iii. Proper distribution of temporary electric power (use of RCDs/ELCBs, switch gear, cabling, socket outlets)

iv. Proper guarding of shafts, stairs and floor edges up, to a height of 42‖.

v. Proper access stairs and ladders with handrails

vi. Properly demarcated passageways, which are kept clear of materials,equipment, and rubbish

vii. Daily cleaning of debris and rubbish from the site

viii. Adequate temporary lighting

ix. Proper housekeeping to reduce slipping and tripping hazards.

x. Proper protection to pedestrians and adjoining buildings

xi. Contractor‘s all-risk Insurance policy to be in place.

## 1.18 GUARANTEES/WARRANTEES FOR EQUIPMENT/PLANT

a. The period of guarantee/warrantee on the equipment/plant shall be the period stated in the Conditions of Particular Application.

b. The Contractor‘s guarantee does not cover the normal wear & tear.

c. Manufacturer's equipment warranties if they exceed the Maintenance Period as defined in these Documents, shall be transferred to the Employer at the end of the Maintenance Period.

d. The Contractor shall guarantee that the material & workmanship incorporated into the plant/equipment are new and the best of their respective kinds for the service intended and that all items will be free from inherent defect in design, workmanship& materials, and that all equipment in its several parts will operate successfully at all capacities up to and including the maximum specified load without undue noise, heating, straining of parts, wear and vibration and that an ample factor of safety is included in every design.

e. Guarantee/Warrantee, shall be furnished by the Contractor upon forms approved by the Engineer Incharge and shall be signed by both the Contractor and the Sub- Contractors whose work is involved.

f. If the equipment/plant manufacturer's standard guarantee/warrantee is applicable, the guarantee/warrantee form and conditions must be submitted along with the equipment/plant technical submittals'.

g. The Contractor's liability shall be limited to the replacement of defective parts that may develop in the equipment or material of his own work or manufacture or his Sub- Contractors under proper use and arising solely from faulty design, material, or workmanship provided always that such defective parts are not repairable at the Site, and are not essential in the meantime for commercial use of the equipment, are promptly returned to the Contractor's or Sub-Contractor's factory unless otherwise arranged. The equipment so replaced or repaired shall be in conformity with the specifications.

h. For indigenous equipment, all replacements shall be made free of cost at the Site by the Contractor.

i. For imported equipment, all replacement shall be made free of cost ex-Karachi port, and the Employer shall arrange to have then cleared, pay all duties and hand-over the replaced parts to the Contractor.

j. The return of defective parts to the Contractor's or Sub-Contractor's factory shall be the Contractor's responsibility and shall be made at his expense. The Employer will, however, render such assistance as necessary to expedite the same. In the case of defective parts not repairable at the site but essential in the meantime for the commercial use of the equipment, the Contractor shall, whenever possible, replace free of cost at the site the said defective parts before the defective parts are removed from the site.

k. If it becomes necessary for the Contractor to replace or renew any defective portions of the Plant under this clause, the provisions of this clause will apply to the portionsof the plant so replaced or renewed until the expiration of six months from the date of such replacement or until the end of the guarantee period, whichever shall be later. If any defects are not remedied within a reasonable time, the Employer, after due notice to the Contractor, may proceed with the work at the Contractor's risk and expense without prejudice to any other rights which the Employer may have against the Contractor in respect to such defects.

l. If the replacements or renewals are of such a character as may affect the efficiency of the plant, the Engineer Incharge shall have the right to give to the Contractor within one month of such replacement or renewal, notice in writing that performance tests be made, in which case tests shall be carried out as provided in these Documents. Should such tests show that the guarantees of the Contract are sustained, the cost of the tests shall be borne by the Employer. Should the guarantees not be sustained, the cost of the test shall be borne by the Contractor.

m. If during the guarantee period the services of the Contractor's personnel are required for the rectification or replacement of any defective part or work due to defective material, design or workmanship, such services shall be made by the Contractor without charge to the Employer.

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## 1.19 TESTS ON COMPLETION

a. The Contractor shall give to the Engineer Incharge in writing 15 days' notice of the date after which he will be ready to make the ―Tests on Completion‖. Unless otherwiseagreed the tests shall take place within 10 days after the said date on such day or days as the Engineer Incharge shall in writing notify the Contractor.

b. If the Engineer Incharge fails to appoint a time after having been asked to do or to attend at any time or place duly appointed for making the said tests, the Contractor shall be entitled to proceed in his absence and the said tests shall be deemed to have been made in the presence of the Engineer Incharge.

c. If in the opinion of the Engineer Incharge the tests are being unduly delayed he may, by notice in writing, call upon the Contractor to make such tests within 10 days from the receipt of the said notice, and the Contractor shall make the said tests on such day within the said 10 days as the Contractor may fix and of which he shall give noticeto the Engineer Incharge. If the Contractor fails to make such tests within the time aforesaid, the Engineer Incharge may himself proceed to make the tests. All tests so made by the Engineer Incharge shall be at the risk and expense of the Contractor.

d. The Employer, except where otherwise specified, shall provide free of charge subject to the provisions of Sub-clause (e) of this clause; electricity, fuel and water, as maybe reasonably demanded to carry out such tests efficiently.

e. If any portion of the works fail to pass the tests, tests of the said portion shall, if required by the Engineer Incharge or by the Contractor, be repeated within a reasonable time upon the same terms and conditions, as aforesaid, save that all expenses to which the Employer may be put by the repetition of the tests shall be deducted from the Contract Price.

## 1.20 INSPECTION OF COMPLETED WORKS

a. The Contractor is required to give the Employer/ Engineer Incharge due notification when he expects the work to be completed, a report in triplicate of the measurements carried out with regard to pressure testing of pipes and leak testing of duct work and other specified tests shall be attached to this application. The final inspection should then be carried out, without unnecessary delay, and if possible within four weeks.

b. At the request of either party, inspection of such Sections of the work as will not be accessible after completion, or will be difficult to alter, which are to be taken into use by the Employer before the time of the final inspection, may be carried out in advance. (Advance Inspection).

c. An inspection is to be carried out immediately before the expiry of the guarantee period. (Guarantee Inspection).

d. Inspection of corrected faults or omissions noted in connection with advance, final, or guarantee inspection is also to be done (Supplementary Inspection).

e. Inspections are to be carried out by the Engineer Incharge or any other suitable and competent person appointed by the Employer.

f. The costs of Advance Inspection, Final Inspection & Guarantee Inspection are to be met by the Employer, where the inspection has been carried out by a person appointed by him. The costs of supplementary inspections and re-inspections are to be borne by the Contractor. It is the responsibility of the Contractor to provide & pay for, any help or assistance necessary in connection with the inspection work.

g. The inspector's decision as to what faults or omissions may have occurred is binding on both sides.

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h. The Contractor is required to carry out, without delay, any improvements, alterations or additions which may be considered necessary as the result of an inspection report.

i. When the final inspection has taken place, the work is to be handed over to the Employer in so far has been found to be in the state required by the Contract, and can suitably be put into use for this purpose for which it was intended.

j. The Employer has the right to put into use any Section of the work contracted for and not approved at the time of inspection, provided this can be done without jeopardizing the progress of the work, and he may use it without special compensation even beforethe faults or omissions have been made good.

k. Where special dates are specified under the Contract for the completion of different Sections of the work, the provisions of this Clause are to apply to each part separately.

l. The inspection report required under this Clause is to be delivered in writing, and signed by the inspector, giving the date on which it is to be made available for the parties' inspection. The report should cover the following points:

   i. State whether the work has been approved or not.

   ii. State the reasons for failing to approve it, if it has not been approved.

   iii. State faults or omissions for which the Contractor is to be held responsible, together with the time within which they are to be made good.

   iv. Include notes on matters which do-not require immediate action, but ought to be finally settled in connection with the guarantee inspection.

   v. The sum to which the Employer is entitled.

   vi. Date on which the insurance taken out by the Contractor lapses.

   vii. If the work has been approved at the final inspection, the date from which the guarantee/maintenance period is to run and the day after which it expires.

   viii. Distribution of costs connected with the inspection.

## 1.21 ACCEPTANCE & INTERIM OPERATION

After the performance tests, if the equipment supplied by the Contractor is found to meet the guarantee and any other specified requirement, and if all other work called for hereunder has been completed, the Employer's acceptance will be forth-coming and final payment will become due as provided for under the terms of payment. This acceptance shall, however, not relieve the Contractor of his responsibility for the first inspection.

Should the equipment furnished by the Contractor fail to operate as required, or in case of failure to meet any of its guarantees, the Employer shall have the right to operate the equipment, using the Contractor's supervisory operating personnel, until such defects have been remedied and guarantees met with. In the event that defects necessitate the rejection of the equipment or any part thereof, the Employer shall have the right to operatethe equipment until such time as new equipment is provided to replace the rejected equipment. Such operation shall not be deemed as an acceptance of any equipment.

***END OF SECTION***

# PLUMBING WORK

## 1.0 SCOPE

The work under this section consists of providing all material and equipment and performing all the work necessary for the execution and completion including testing and commissioning of all systems of plumbing works as shown on the Drawings and/or as specified herein and/or as directed by the Engineer Incharge, the systems included in plumbing works are as follows:

i) Cold and Hot Water Supply
ii) Sanitary Drainage
iii) Fire Protection
iv) Roof Drainage

All the above named systems shall be completed in all respects including extension of these internal systems up to the specified limits outside the building as indicated on the drawings.

## 2.0 GENERAL

All the materials and equipment's shall be of the specifications mentioned herein and the Contractor shall submit the sample, necessary catalogues. Sketches the name of manufacturer and guarantee if necessary before installation. The system shall be installed after the approval of the Engineer Incharge. All material and equipment shall be new and unused.

Any material or labor which is usually furnished as a part of the specified equipment and which is necessary for its proper completion and best operation shall be furnished as a part of this Contract without any additional cost whether or not shown in detail on the drawings or described in detail, in the specifications.

Misuse of plumbing fixtures to be installed under this Contract is prohibited during the currency of the contract.

All metal fixture trimmings shall be thoroughly covered with non-corrosive grease which shall be maintained until all work is completed. Upon the completion of work, all fixtures and trimmings shall be thoroughly cleaned, polished and left in first class condition.

Before erection, all pipes, valves, fittings, etc. shall be thoroughly cleaned of oil, grease or other material.

All special tools for proper operation and maintenance of the equipment provided under this Contract shall be delivered at no additional cost.

The Contractor shall allow in his bid for cost of all cutting, making holes and subsequent making it good to the desired finish as per approval of the Engineer Incharge. No separate payment shall be made for this item.

The Contractor shall allow in his bid for the cost of providing protective painting or coating as specified in the relevant sections and no claim shall be entertained for this item.

All pipes shall be properly installed as shown on the drawings and/or as directed by the Engineer Incharge, and shall be as straight as possible forming right angles and parallel lines with the walls and other pipelines The position, gradients, alignment and inverts shall be as shown on the drawings and/or as directed by the Engineer Incharge.

The arrangement, positions and connections of pipe fittings and appurtenances shall be as shown on the drawings. Special precautions shall be taken for the installation of concealed pipes as shown on the drawings and/or as required. Should it be necessary to correct piping so installed, the Contractor shall be held liable for any injury caused to other works in the correction of piping. The Contractor shall closely coordinate with other works during the entire stage of execution.

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A minimum distance between different services shall be maintained as shown on the Drawings and/or as approved by the Engineer Incharge.

Pipes should be installed in such a manner that minimum distance should always be maintained between pipe and wall, beams, columns, etc. Pipes shall be supported on hangers and brackets as shown on the drawings or as directed by the Engineer Incharge.

Waste-water outlet from each fixture shall be individually trapped.

Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building.

When the roughing-in is completed, the plumbing system shall be subjected to test prior to concealing the roughing-in, in order to ascertain that all threads and connections are watertight.

## 3.0 PIPE

Pipe for the various systems shall conform to the following:

A. Sanitary Waste, Drain, and Vent Piping:

1. All gravity flow piping inside or below floor to points five (5) feet outside the building, except as otherwise noted - Schedule 40 polyvinyl chloride (PVC) Type DWV per ASTM-D-3965 and conform to the National Sanitation Foundation (NSF) Standard 14.
2. All exterior below grade piping beginning five (5) feet outside the building - SDR35 heavy wall PVC sewer pipe, hub and spigot type, per ASTM D3034.
3. Any size exposed within a finished room or installed in locations not having sufficient space to conceal completely all parts of pipe and fittings or hard drawn copper tubing, shall be heavily chromium plated where exposed to view.

B. Potable Hot and Cold Water Piping:

1. Domestic underground service lines outside buildings and entering buildings to points one (1) foot above floor slabs on fill grade (limited to domestic service entering the building) - AWWA C900 Class 200 (DR-14) PVC hub and spigot or mechanical joint water pipe.
2. Within building, above ceilings and beneath suspended floors: Type "L" hard drawn copper tubing.
3. Within building, below slabs on grade: Type "L" soft copper tubing, with no below grade joints.

C. Any size piping exposed within a finished room or installed in locations not having sufficient space to conceal completely all parts of cast iron pipe and fittings or hard drawn copper tubing, shall be heavily chromium plated where exposed to view.

## 3.01 FITTINGS

Fittings for the various systems shall conform to the following:

A. Sanitary Waste, Drain, and Vent Piping:

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1. With Schedule 40 PVC pipe: Polyvinyl Chloride Type DWV per ASTM D-2661 with solvent weld joints per manufacturer's direction.

2. With SDR heavy-wall sewer pipe - reinforced hub and spigot fittings of same material as pipe, per ASTM D3034.

B. Potable Hot and Cold Water Piping:

1. With Class 200 PVC Piping - Class 200 AWWA cast iron hub and spigot fittings, OR Class 200 AWWA cast iron mechanical fittings, stuffing box type, with suitable gasket; and with concrete thrust block at each elbow or tee.

2. With copper pipe - wrought copper, pressure type, solder joint fittings, same class as pipe.

## 3.02 FERRULES

All ferrules shall be of the best quality, extra heavy cast brass not less than 4" long and of weight and size as follows:

| I.D. | LENGTH | WEIGHT |
|---|---|---|
| 2-1/4" | 4-1/2" | 1# - 4 oz |
| 3-1/4 " | 4-1/2" | 1# - 14 oz |
| 4-1/4" | 4-1/2" | 2# - 8 oz |

## 3.03 PIPING DEVICES

The specifications for piping devices such as cleanouts, traps and drains, and downspout nozzles, represent the minimum standard of quality required for this project. Equivalent styles and types of devices furnished by the approved manufacturers will be acceptable:

## 3.04 CLEANOUTS

A. Cleanouts, except at traps and fittings on horizontal branches shall be of same material and of same size as pipe up to 4" and 4" size for all larger pipe.

B. Cleanouts in steel piping shall consist of a threaded drainage fitting, with an extra heavy cast brass or bronze raised head screw plug. Where concealed behind finished wall surfaces, a cast round flush cleanout access cover with polished top, anchor lugs, and vandal-proof cover securing screws, shall be provided also.

C. Cleanouts in PVC piping shall be constructed with wye fittings, sweep elbows and screw plugs. Where clearance is limited, or where otherwise permitted by the Architect, such cleanouts may be tapped tee branch type with raised head screwplug.

1. Cleanouts in PVC piping, not occurring in finished floors or walls, shall haveraised head screw plugs. Where cleanouts are tapped tee branch type, screw plugs shall be raised head type with tee and cover for wall.

2. Cleanouts in PVC piping in finished walls shall be similarly constructed, but provided with raised head screw plug, and stainless steel round flush access cover with polished top, anchor lugs, and cover plate secured to plug by countersunk vandal-proof screw.

3. Cleanouts in PVC piping in finished floors (except where floor is terrazzo or carpeted) shall be similarly constructed as to piping, but provided with cast round flush cleanout with flanged rim, anchor lugs, and inside caulk connection.

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4. Cleanouts in PVC piping in terrazzo floors shall be similarly constructed as to piping, ferrule, and plug, but provided with a cast round terrazzo floor access frame and cover, secured with vandal-proof screws.

5. Cleanouts in PVC piping in carpeted floors shall be similarly constructed as to piping, but provided with caulking ferrule, threaded extra heavy brass or bronze screw plug, adjustable height cover section with heavy-duty scoriated cover and with 1-1/4" diameter carpet marker with vandal-proof screw.

D. Exterior cleanouts, unless otherwise specifically noted, shall be brought up flush with paving in paved areas, or encased in an 18" x 18" x 6" reinforced concrete pad flush with grade in unpaved areas, and terminated with an extra heavy cast iron caulking ferrule having an extra heavy cast brass or bronzecountersunk head screw plug.

## 3.05 TRAPS AND DRAINS

A. P-traps shall be placed under all floor drains and at other points indicated on the drawings, or otherwise required. P-traps in PVC piping shall be Schedule 40ABS PVC with trap primer. Where so noted, traps shall be "deep seal" type, with seal not less than 4" for 2" size or not less than 5" for larger sizes.

B. Floor drains in mechanical rooms shall (except as otherwise specifically noted) will be cast iron round drain, with double drainage flange, weep holes, inside caulk bottom outlet, flashing clamps, loose set heavy duty nickel-bronze grate, and removable sediment bucket, with trap primer.

C. All other floor drains and all shower drains shall be cast iron floor drains with double drainage flange, weep holes, inside caulk bottom outlet, and round adjustable nickel-bronze strainer. Strainers shall be provided with vandal-proofscrews, with trap primer.

D. All sanitary floor sinks shall be with acid-resisting interior, double drainage flange, dome strainer, and anti-tilt grate, with trap primer (half grate where noted).

## INSTALLATION

## 4.0 SANITARY DRAINAGE SYSTEMS

A. The Contractor shall furnish and install the various systems of sanitary drainage indicated on the plans. Each shall be complete soil, waste, and vent systems for allcloset, lavatories, sinks, urinals, drinking fountains, electric water coolers, floor drains, etc. Waste and vent piping shall be sized as shown on the plans, and arranged to give proper drainage and venting for each fixture. All work shall be done in strict accordance with currently adopted codes (i.e., Uniform or International Plumbing Code, etc.), which shall be followed in case of conflict withthe plans.

B. Soil, waste, drain, and vent piping within the building shall be given a uniform grade of 1/4" per foot wherever possible, but in no case less than 1/8" per foot (limited to3‖ and larger). All exterior piping shall be installed to the flow lines indicated on the plans, and laid with 12" earth cover, minimum. Contractor shall verify all levels between the building and main sewer at the beginning of the job, and if the specified grades cannot be maintained, the Architect shall be so informedbefore proceeding with the work.

C. All soil, waste, and drain pipes shall be extended full size as vent pipes to above the roof lines as shown. Where so indicated, or elsewhere with the approval of theArchitect, two or more vent risers may be connected in roof space and vents extended through roof. Each riser extended through roof shall project at least 15"above roof line and shall be thoroughly flashed with 4 lb. lead flashing turned down inside vent stack, and

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extended under roofing not less than 12" in all directions from vent pipe. Vent risers smaller than 2" shall be provided with approved brass vent caps in lieu of turning flashing down into pipe.

1. Contractor shall take care to coordinate vent riser locations through roofs with A/C outside air intakes as required to maintain a minimum separation of at least fifteen feet (15‘) where possible, and in no case less than ten feet (10‘).Necessary offsets of vent lines shall be provided to meet this requirement whether or not indicated on the drawings at no additional cost.

2. For flat roof areas with parapets, the top discharge of all vent lines through roof shall be set at top of parapet, but in no case less than 15‖ above the roof line. Taller vent stacks shall be provided with proper supports and flashing as required by the Roofing Contractor.

3. For hip roof construction, all vent risers through roof shall be located on the back side of the roof ridge where possible.

4. Upon request by the Employer, Contractor shall be prepared to furnish and install ―Sweet Filter II‖ vent filters at designated vent stacks as may be foundnecessary to eliminate sewer gas odors from re-entering the building. Installation of up to five (5) vent filters shall be included in the Contractor‘s bid.

D. The soil, waste, drain, and vent piping shall be provided with cleanouts to make all sections of the system accessible. Cleanouts shall be provided at the ends of change in direction of all drain, soil, and waste pipes and branches thereof, at thefoot of each riser, at all offsets, in horizontal runs at approximately 60' intervals and 100‘ intervals outside the building, and at other points where indicated on the drawings or where required. Two-way cleanouts shall be provided at the discharge of grease traps.

E. All trenching for soil, waste, or drain lines shall be graded so that the pipe rests on 12" sand base. Sand base shall be tamped to the satisfaction of the Architect. Trenching shall have bell holes at each joint, to allow body of pipe to rest on ground and to provide space for joint makeup. All drain inlets shall be covered and suitably protected from tile slurry, dirt, debris, etc., during construction. Wash down of such materials into building drain inlets is strictly prohibited.

## 4.01 POTABLE WATER SYSTEMS

A. This Contractor shall furnish and install the various potable hot and cold water systems as indicated on the plans. Systems shall be complete from points of connection to mains as indicated through or to the various equipment items furnished by the Employer, or under this or other contracts, and to points of connection with all plumbing fixtures or other outlets requiring same.

B. All interior piping will be graded for gravity drainage toward main supply risers or to fixture connections, to allow complete drainage of all parts of the system.

C. Underground piping shall be laid with 36" minimum cover to finished grade.

D. All connections of water piping to equipment or to piping of dissimilar metals shall be made with dielectric isolating couplings.

## 4.02 PIPING, HANGERS, SUPPORTS, ETC., GENERALLY

A. All piping shall be installed parallel or perpendicular to the lines of the building, unless distinctly shown or noted on plans otherwise. Spacing of lines shall be such as to provide not less than 1" clearance between finished coverings on the various services.

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B. This Contractor shall furnish all foundations, hangers, or supports for the work installed.

1. All suspended drainage piping shall have supports not more than 5‘ on centers. All horizontal runs of cast iron or PVC waste and vent piping with no-hub couplings or solvent weld joints shall include supports immediately on either side of each joint.

2. All suspended piping shall have supports not more than 5' on centers for sizes under 2", and not more than 10' on centers for sizes 2" and larger.

3. All vertical risers shall be supported at each floor with vertical riser clamps and not more than 10‘-0‖ intervals.

4. Supports at special conditions shall be as detailed on the plans.

C. All anchors in structural concrete shall be ¯Code-approved‖ anchors.

D. Supports to walls shall be made with molly bolts.

E. Perforated strap hangers shall not be used for any work.

F. Insulation protection saddles, as specified hereinafter, shall be used at the following locations:

1. At pipe hangers on insulated hot and cold water lines.

2. At trapeze hangers on any insulated piping.

3. At pipe rollers or other framed supports on any insulated piping.

G. Hangers for piping shall be adjustable split ring malleable iron or steel clevis type with threaded rod and turnbuckle in rod where hanging height permits. Except as otherwise specified, hangers shall be sized to fit the pipe.

1. Hangers shall be sized to fit the outside diameter of all insulated piping.

H. Trapeze hangers may be used for multiple parallel runs where specifically indicated on the plans, or elsewhere with permission of the Engineer Incharge.

I. All pipe openings shall be capped during construction. All steel pipe (except pre-insulated), before installation, shall be stood on end and pounded toremove dirt and scale, and all steel pipes shall be properly reamed before joints are made up.

J. All piping shall be installed so as to allow for expansion and contraction using offsets, expansion loops, swing joints, etc., as shown or as may be required to prevent undue strain on piping.

K. Pipe shall be cut accurately to fit. No bending or springing of pipe will be permitted.

L. All water piping shall be arranged for draining through fixtures, equipment, orto floor drains where necessary, by means of 3/4‖ hose-end drain and ball valve.

M. Piping run on roofs shall be supported on corrosion-resistant pipe rollers with mounting curbs secured to the roof, as detailed on the Architectural Drawings.

N. All piping supports shall be connected to the top cord of joist or beam. Connection of supports to ¯X‖ bracing or cross support structural members is strictly prohibited.

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## 4.03 PIPE JOINTS

A. Except as otherwise noted, joints in threaded piping shall be made only with "Jointite" or equal, applied on the male thread only. The ends of pipes shall be square cut, reamed, and wiped clean before being made up into fittings.

B. Joints in general-purpose copper piping shall be "sweated", except as otherwise noted. Before making up joints, all copper shall be cleaned to bright metal with emery cloth, and treated with "No-Kerrode" or equal flux. Solder shall be lead-free type, composed of 95.5% tin, 4.0% copper, and 0.5% silver, similar and equal to "Silvabrite 100".

C. Joints in welded piping shall be made up with factory fabricated welding fittings as specified above which shall include all elbows, tees, laterals, reducers, etc., and shall be "Tube-Turn", "Taylor Forge", "Ladish", or "Crane" full radius type, except that tees may be formed for lines 4" and larger connecting to lines 6" and larger by saddling branch into side and main and connection of lines 1- 1/2" and smaller into lines 2" and larger may be made with "Threadolets". All welding shall be done in accordance with standard practice utilizing only fully qualified welders, in accordance with Section IX of ASME Boiler and Pressure Vessel Code, and ANSI B31.1. All joints shall be smoothly fitted before welding, and welding rod shall be specifically suited to the pipe material. Flanges shall be weld-neck type, class to match valve, except #150 minimum.

D. Joints in PVC piping shall be U.L. listed solvent welded type with application and use of primer and solvent supplied and recommended by the manufacturer, and conforming to ASTM F-656 and F-493.

E. Joints in SDR heavy-wall PVC pipe shall be made up with vulcanized natural or synthetic rubber compression gaskets in factory-fabricated joint sections. Pipe and fitting ends shall be properly lubricated with an approved solution, and installed in strict accordance with manufacturer‘s instructions.

## 4.04 CLEANING, TESTING, AND ADJUSTING

A. It is the intent of this section of the specifications to provide for the thorough cleaning of the interior and exterior of all piping systems, and for all necessary tests during and at completion of the job to insure tight piping and correctly balanced systems. This Contractor shall do any and all work required to accomplish this end.

B. The various drainage and vent piping systems, and storm drainage systems throughout shall be tested upon completion of the rough work and with fixtures or traps connected. All openings, except at the tops of stacks shall be tightly closed by screw plugs or equivalent devices, and the systems shall be entirely filled with water, applied at minimum 10 feet of head, which shall stand without leak or loss of level for a period of four hours.

C. All potable hot and cold water piping, prior to being insulated, shall be tested in place to an air or hydrostatic pressure of 125 pounds per square inch at the first floor level for interior piping and the low point of the system for exterior piping, which pressure shall be maintained without pumping for a period of one hour.

D. Pressure gauges shall be installed to confirm each piping test.

E. All new strainers and filters shall be cleaned after pressure testing and system cleaning operations, and prior to final filling of systems.

F. All motors, bearings, etc., on all equipment shall be correctly oiled and/or greased with proper lubricant before the equipment is operated, and again at completion ofthe job.

G. The Contractor shall conduct operating tests of all equipment and other apparatus installed by him to demonstrate to the Employer and the Engineer Incharge the satisfactory operation of same and the fulfillment of the specified requirements. He shall make any additional tests

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that may be required by other authorities.

## 4.05 STERILIZATION OF POTABLE WATER LINES

A. Before being placed in service, all potable hot and cold water piping systems shall be sterilized with a chlorine cleaning solution and shall be completely flushed and rinsed out with cold water, as required by the Punjab Department of Public Health.

B. Contractor shall provide and pay for a ¯Service Inspection & Testing Certificate‖ as required by the Engineer Incharge.

## 5.0 PLUMBING FIXTURES

### 5.1 Scope

The work under this section of the specifications consists of providing all material and labor for supply and proper installation of plumbing fixtures of wash basins, kitchen sinks, laboratory sinks, water closets, urinals, etc. along with all their accessories, water inlet connection, waste outlet connection etc. complete in all respect as specified herein or as shown on the Drawings and/or as directed by the Engineer Incharge.

### 5.2 Materials and Installation

#### 5.2.1 General Requirements

Materials shall conform to the latest referenced standard specifications and other provisions stipulated herein and shall be new and unused.

All fixtures shall be of high class quality and finish and shall be of approved manufacture.

Prior to procurement of the materials, the Contractor shall be required to prepare and submit to the Engineer Incharge for his approval, a complete schedule of materials to be used in the works together with a list of the names and addresses of the manufacturers and the trade names of the materials. The schedule shall include diagrams; drawings and such other technical data as may be required by the Engineer Incharge to satisfy himself as to the suitability, durability, quality and usefulness of the materialto be purchased.

Approval of the schedule shall not be construed as authorizing any deviations from the specifications unless the attention of the Engineer Incharge has been invited to the specific changes. If the material or equipment offered under this provision is, in the opinion of the Engineer Incharge, equal to or better than specified, it will be given consideration.

Plumbing fixtures shall have smooth impervious surfaces, be free from defects and concealed fouling surface. They shall be true to line, angles, curves and color etc. Normally they shall be of local make and of the best quality available, provided.

All taps and cocks to be installed with plumbing fixtures shall be chrome plated (CP) and shall be of appropriate class to work without damage or leakage on the specified pressure of potable water system.

When any fixture is provided with an overflow, the waste shall be so arranged that the standing water in the fixture cannot rise in the over flow when the stopper is

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closed or remain in the overflow when the fixture is empty.

Plumbing fixtures shall be installed in a manner to afford easy access for cleaning. The space between the fixture and the wall shall be closely fitted and pointed so that there is no chance for dirt or vermin to collect.

When practical, all pipes from fixtures shall be run to the nearest wall.

Where fixture comes in contact with wall and floors, the joint shall be watertight.

Wall hung fixtures shall be rigidly supported by metal supporting members so that no strain is transmitted to the connections. Flush tanks and similar appurtenances shall be secured by approved non-corrosive screws or bolts.

Fixtures shall be set level and in proper alignment with reference to adjacent walls. No water closet shall be set closer than 1.25 ft. from its center to any side wall. No urinal shall be set closer than1.0 ft. from its center to any side wall or partition or closer than 24 inch center to center.

The supply lines or fittings for every plumbing fixture shall be so installed as to prevent back flow.

All cuttings, making holes etc. and making it good shall be included in the work.

5.2.2 Water Closets (Asiatic)

Squatting type water closet including foot rest of Vitreous China shall be of approved color, manufacture and size. It shall be installed as a complete unit including cast iron P-trap, 1/2 inch. CP tee stop cock with wall cups, plastic water inlet connection pipe. Plastic water flush tank with all internal fittings, installed at low level including inter connecting flush piping and sealing material etc. with all other minor accessories or as approved by the Engineer Incharge.

5.2.3 Water Closets (European Type)

European type water closet of vitreous China with close coupled flush tank shall be of approved color, manufacturer & size or as approved by the Engineer Incharge.

Trap shall be cast integral with pan. The seat shall be of smooth non- combustible non-absorbent materials like Bakelite and of the open front type fixed to the pan with hinges.

The fittings shall also include 1/2 inch tee stopcock, with wall cover, plastic water inlet connection pipe nuts bolts etc. required for installation.

Disabled WC Apparatus, European Pattern

Disabled WC Apparatus, European Pattern, complete (coupled set), comprising closet 13 lit flushing cistern glazed, in white colour, seat cover, rails, handle etc complete set (IFO Porta, Marchi pattern or equivalent), fixed to concrete, brick, stone or wood work, best quality as per instruction of Engineer incharge.

Urinal

Urinal, basin/stall pattern best (imported vide or equivalent quality white) or as

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approved by the Engineer Incharge, including connection to out-going pipe and to flushing pipe complete.

5.2.4 Sinks

Sink shall be stainless steel of approved make single bowl with integral drain board of specified size. It shall be installed as a complete unit with 1/2″dia. cold and hot water C.P mixer, CP brass strainer, CP brass waste outlet and UPVC waste pipe, heavy cast iron brackets with bolts screws etc. Joints, jointing and sealing material, etc., with all other minor accessories or as approved by the Engineer Incharge.

5.2.5 Shower / Mixer

Shower head shall be local best quality chromium plated adjustable type installed on the wall at suitable height, complete with cold and hot water mixer and all accessories such as chromium plated extension pipe, C.P. brass escutcheon etc. It shall be mounted on the wall at a suitable height near the shower head complete with all accessories or as approved by the Engineer Incharge.

5.2.6 Wash Basin

Wash Basin with pedestal, glazed ware, Imported (China) (like Porta design or equivalent) / local in white / Ivory colour or as approved by the Engineer Incharge with one hole, complete with waste pipe coupling, CP chain and plug and pedestal etc (except mixer) best quality, fixed to concrete, brick stone, or wood work or as approved by the Engineer Incharge.

5.2.7 Disabled Bath Wash Basin

Disabled Bath Wash Basin, glazed ware, Imported (like Porta, Marchi design or equivalent) in white / Ivory colour, or as approved by the Engineer Incharge one hole, complete with waste pipe coupling, CP chain and plug, automatic mixer etc best quality, fixed to concrete, brick, stone or wood work as per instruction of Engineer Incharge.

5.2.8 Mirror

Mirror, any shape and pattern, circular, rectangular, oval etc upto 2700 sqcm, 5 mm thick, Imported (mirror foreign made, but frame Pak made) with plastic frame, any colour, edges ground, or as approved by the Engineer complete, fixed to concrete, brick stone, or wood work.

5.2.9 Towel Rail, CP

Towel Rail, CP, single rod, any pattern, shape and size, imported, or as approved by the Engineer with plugs, screws etc complete, fixed to concrete, bricks, stone or wood work.

5.2.10 Toilet Paper Holder

Toilet Paper Holder, any shape pattern and size, imported, or as approved by the Engineer with plugs, screws etc complete, fixed to concrete, bricks, stone or wood work.

5.2.11 Soap / Sponge Tray

Soap / Sponge Tray any shape pattern and size, imported, or as approved by the Engineer complete with plugs, screws etc complete, fixed to concrete, bricks, stone or wood work.

5.2.12 Brush / Tumbler Holder

Brush / Tumbler Holder any shape pattern and size, Imported / Local complete or approved by the Engineer with plugs, screws etc fixed to concrete, bricks, stone or wood work.

5.2.13 Muslim Shower

Muslim shower with double bib cock & ring pipe etc complete importedquality like Grohe or equivalent) or as approved by the Engineer.

5.2.14 Testing and Commissioning
All fixtures shall be tested for soundness, stability or support and satisfactory operation.

## 6.0 MISCELLANEOUS ITEMS

### 6.1 Scope

The work under this section of the specifications consists of providing all material and labor, equipment, appliances etc., for supply and proper installation of miscellaneous plumbing items valves, cocks, floor traps, floor drain, clean outs, mirror, electric water cooler, gas water heater, float valve, foot valve, irrigation outlet etc. as specified, herein or as shown on the Drawing or as directed by the Engineer Incharge. The Contractor shall furnish appropriate catalogues and literature and obtain approval of the Engineer Incharge before purchase,

### 6.2 Material and Installation

6.2.1 Bronze Valves

All valves of 100 inch diameter and smaller shall be of bronze unless otherwise specified conforming to BS 5154 and shall be of appropriate class for the working pressure of the system on which they are installed. Open and shut indicators shall be marked on the spindle. The ends may be screwed or flanged.

6.2.2 Taps and Cocks

All the taps and cocks shall be of brass, gunmetal or other equally suitable

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corrosion resisting alloy conforming to BS 1010 and shall be imported in addition be chrome plated. The nominal size specified shall be the nominal bore of the seating. The area of the waterway throughout the body shall be not less than the area of a circle of diameter equal to the nominal size of tap/cock. Washers for cold water cocks shall be of specially selected leather, rubber asbestos composition or other equally suitable material. Every tap/cock shall be tested, complete with its component parts, to a hydraulic pressure of at least one and half times working pressure. During test it shall neither leak nor sweat.

6.2.3 Floor Drains

Floor drains shall be of cast iron or of other anti-corrosive metal. They shall have minimum water seal of 3/4 inch and shall be provided with removable metal strainers. The traps shall be of self-clearing type. The open area of the strainer shall be at least equal to the cross section area of the drain line to which it connects. Floor drains shall have provision for connection above the water seal. Floor drain shall be well set in position so that there is no leakage at the joint between trap and the floor.

6.2.4 Cleanouts

Clean outs shall be of the same nominal size as that of the pipe on which it is installed. Cleanout shall consist of tapped heavy duty cast iron ferrule caulked into cast iron fitting and heavy duty brass tapered even plug. Cleanouts shall be turned up through floors by long sweep fittings, wherever the space so permits. Top finish of cleanout shall be flush with the floor by means of finished metal plate secured in position and screwed firmly to the plug.

Cleanout shall be so installed that there is a clearance of at least 12 inches for pipes less than 3 inches diameter and at least 18 inches for pipes of 3 inches and larger diameter, for the purpose of rodding.

6.2.5 Floor Traps

Floor traps shall be of cast iron or of other corrosive metal. They shall have minimum water seal of ^ inch, and shall be provided with removable nickel bronze strainers, the traps shall be of self-cleaning type. The open area of the strainer shall be greater than the cross section area of the drain line to which it connects. Floor traps shall be well set in position so that there is no leakage at the joint between trap and the floor.

6.2.6 Float Valve

Float valve shall be of copper alloy, piston type and conform to BS 1212. Float shall be of copper conforming to BS 1968 where required or indicated on the drawing

6.2.7 Foot Valve

Foot valve shall be installed on the suction line of the pumps where required or indicated on the drawing. Foot valve shall be of brass, and shall be provided with integral strainer. Foot valve shall be provided with a spring loaded vertical check disc with gasket for tight shut-off.

6.2.8 Floor Gully

Floor Gully's shall be of cast iron or of other anticorrosive metal, and provided with removable nickel bronze strainers. The open area of the strainers shall be greater than the cross section area of the drain line to which it connects. Floor gullies shall be well set in position so that there is no leakage at the joint between

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gully and the floor. Therefore floor gully where required or indicated on the drawing.

6.2.9 Gully Traps

Gully traps in block masonry chamber as shown on the drawing shall be provided with a P-trap having a 1 inch minimum water seal and a cast iron frame and cover of size 12" x 12" and shall be internally plastered with pudlo as approved by Engineer Incharge.

6.2.10 Cowel

All vent pipe terminating above the building shall be provided with best quality cast iron cowl and a stainless steel clamp for clamping of water proofing membrane as approved by the Engineer Incharge.

6.2.11 Orifice Plates

Where the static pressure at any connection exceeds limits an orifice plates shall be installed prior to the valve to reduce the water flow so that pressure does not exceed the required limit. The orifice plate shall be constructed of 12mm thick stainless steel plate and shall be installed between two steel flanges. Size of orifice shall be as obtained from the Engineer Incharge prior to fabrication.

## 7.0 ROOF DRAINAGE

7.1. Roof Drains

Roof drains shall be Upvc pipes. They shall have dome shaped strainers extending above the roof surface. Bottom of strainer shall be flush with the roof surface. Strainer shall have an available inlet area, above roof level, of not less than 1-1/2 times the area of the down-pipe to which the drain is connected. The connection between roof and roof drain shall be made watertight by the use of proper flashing material.

7.2 Rain Water Shoe

Rain water shoe shall be of bitumen/asphalt coated cast iron, anti-splash type to B.S. 416. The grade of shoe shall be same as that for rain water pipe to which it connects. The shoe shall be fixed 12 inches above the surface to which it dischargesfreely.

## 8.0 UPVC PIPE & FITTINGS

8.1 UPVC Waste and Vent Pipes & Fittings

Unplasticized PVC pipes for waste and vent shall be non-pressure pipes conforming to BS-4514. Fittings and specials for use with UPVC pipes shall conform to BS-4346 with elastomeric (Rubber ring) or solvent cement joint to BS-4346, Clamps hangers and supports shall be as required for G.I. pipes.

## 9. GALVANIZING:

Galvanising shall comply with BS 729. The term ‗galvanised' shall apply to hot dip or electrolytic galvanising, zinc spraying or cadmium plating. All surfaces shall be degreased, washed with mineral turpentine and given a coat of latex based primer prior to the application of final coats. After fabrication, pickle or abrasive blast clean all steelworks to be hot dipped galvanised.

**10.** SEQUENCING AND SCHEDULING:

a. Coordinate plumbing piping and equipment installation with other building components.

b. Arrange for chases, slots and openings in building structure during progress of construction, to allow for plumbing installations.

c. Coordinate the installation of required supporting devices and set sleeves in poured in-place concrete and other structural components, as they are constructed.

d. Sequence, coordinate and integrate installations of mechanical materials and equipment for efficient flow of the work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

e. Coordinate connection of plumbing systems with other utilities and services. Comply with requirements of governing regulations, service companies, and consultants.

f. Coordinate requirements for access panels and doors where I items requiring access are concealed behind finished surfaces.

g. Coordinate installation of identifying devices after completion of covering and painting, where devices are applied to surfaces. Install identifying devices prior to installation of acoustical ceilings and similar concealment.

***END OF SECTION***

# TESTING AND COMMISSIONING

## 1.0 SCOPE OF WORK

The work under this section of specifications includes visual inspection, furnishing all plant, labor, equipment, appliances and materials and performing all operations required in connection with testing and commissioning of all water line, drainage system and fixture etc. in parts and as a whole as specified herein or as shown in the Contract Documents or as directed by the Engineer Incharge.

## 2.0 GENERAL

The testing shall include a complete visual inspection of the whole plumbing and firefighting system and verification or performance as stipulated in the material specification and of correct functioning of the electrical and control systems.

All supply documents, operating instructions, acceptance documentation and maintenance regulations shall be checked to ensure that they correspond with equipment described and also all certificates such as that of the inspection authorities, test certificates and data about quality, temperature and pressure shall be submitted.

## 3.0 FIXTURES AND FITTINGS

### 3.1 Test Program

The type and the catalogue number of the sanitary fixtures shall be checked.

All equipment in general including the accessories shall be checked for service ability, correct operation and freedom from damage.

The flow and water capacity shall be checked on the full connection of lavatories, showers, WC's, etc. and also the draining capacity shall be measured at the same time.

## 4.0 POTABLE WATER SUPPLY SYSTEMS HOT & COLD

### 4.1 Test Program

The method of laying and sealing the water connection lines to the buildings and through walls shall be checked.

Visual inspections shall be made of the entire network for the water systems with regard to laying, fixing, suspension of pipes and fixtures, particularly the arrangements of the fixed points and the separation of the individual connections in the various parts of the system.

The satisfactory function of all valves, air relief valve check-valves, pressure reducers, thermostats, pumps, etc., shall be checked. The test programme shall alsocover.

Checking of type, thickness and professional laying of the piping insulation. Checking number, form and inscription of the equipment labeling.

Checking of all pipe and flanged connections to devices, water heaters, drainage and vents for symmetry and lack of strain.

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Performance of pressure test for the entire network, including fixtures.

### 4.2 Hydraulic Pressure Test

On completion of the pipe work installation or sections thereof as required, pressure test shall be made before the application of insulation. The pressure tests shall be taken by sectors. All equipment and accessories shall be provided and the Engineer Incharge shall be given notice that the work is ready for testing. Tests shall be made by pumping up the system to the required pressure then closing the valves between the pump and the section under test. The valve shall remain closed for the durationof the test and the pump shall be disconnected. Test pressure, as detailed below shall be applied as detailed for a period two hours or longer, at the discretion of the Engineer Incharge. If, at the end of period, there is no drop in pressure and no evidence of leak or other faults, the test will be considered satisfactory. Should any fault be revealed by the test, leaks are to be recorded, Faults shall be made good and the pipe work retested as many times as necessary until satisfactory results are obtained.

After all the pipes and fixtures have been properly laid and tested, they shall be flushed clean with water and then disinfected with water solution of chlorine of at least 50 PPM strength for a contact period 6 hours. The system will be finally flushedwith clean water.

### 4.3 Test Pressure and Procedure

Fill pipes slowly with potable water to exclude all air. Apply test pressure of 1.5 times the maximum working pressure. There must be no measurable loss of pressure forat least 30 minutes.

## 5.0 DRAINAGE SYSTEMS

### 5.1 Test Program

Check the piping by means of the separation system, In relation to the specified capacity.

Check each connection for dimension and draining capacity.

Check the drain line for laying, fixing, and compliance with specification.

Check the practical arrangement of the fixtures, fixing points, suspensions, cleaning openings, vents, pit covers and ground inlets.

Check all the covers and openings, paying special attention to the separation system for waste/sewage and the storm water.

Generally provide clean water and apparatus for testing.

### 5.2 Test Methods

#### a. Water Testing

All the openings in the piping system shall be tightly closed by inserting testing plug. The highest point will be left open to supply water and may be raised if necessary by temporary jointing, develop a minimum static head of 05 bars for of water at each section of the system. Water is filled to the point of overflow and any drop in the level

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of water will indicate a leak that will be found by inspection. The water level will be checked for no drop for at least 15 to 30 minutes. Higher stacks will be tested in sections, starting from the top section and then connecting top section to next lower section.

**b. Timing**

Testing shall be carried out as soon as practicable after completion of each drainage stack. All concealed work shall be tested before being finally enclosed.

***END OF SECTION**

# DISINFECTION

## 1.0 SCOPE OF WORK

The work under this section of specifications includes furnishing all plant, labor, equipment, appliances and materials and performing all operations required in connection with disinfecting of all potable water lines in parts and as a whole as specified herein oras shown in the Contract Documents or as directed by the Engineer Incharge.

## 2.0 DISINFECTION

After successful completion of pressure tests the entire potable water distribution system in the building shall be thoroughly flushed with water to remove all entrained dirt and mud before disinfecting of the system. The disinfecting chemical shall preferably be hypochlorite solution. However, bleaching powder may be used as alternate material with the approval of the Engineer Incharge. Use of gaseous chlorine shall not be allowed for disinfecting.

The chlorine solution shall be introduced into the system until the system is filled with the solution and all entrapped air is expelled from the system. The solution shall be retained in the system for at least 24 hours.

At the end of the period solution will be tested for chlorine residua, which shall not be less than 10 PPM of chlorine throughout the system.

The disinfections process shall be repeated if chlorine required is less than 10 PPM at anylocation of the system.

After successful completion of disinfection the system shall be flushed with potable water until the residual chlorine is reduced to less than 1 PPM.

During disinfection period all the valves and faucets shall be opened and closed several times to ensure that all parts of the valves are also disinfected.

*** END OF SECTION***

## DRAINAGE / SEWAGE AND SEPTIC TANKS

### 1.0 GULLIES

a. To be glazed ware and are to be set truly level and jointed to drain pipes in cement mortar (1:1). Gullies to be encased in cement concrete (1:3:6).

b. Cleaning eyes are to be provided to gullies, when the distance between the gully and the manhole exceeds 6 meters.

### 2.0 INTERCEPTION CHAMBERS

To be as described for manholes but to include an intercepting trap of approved pattern, with cleaning arm, having an approved stopper fitted with a galvanized iron lever and chain complete. This strap to be carefully bedded in concrete on the discharge side of the manhole and set so as to ensure that the normal ―drop‖ from inlet to outlet is preserved.

### 3.0 LAYING DRAINS

Every line of drain shall be accurately laid and be perfectly true to line and gradient from point to point. Every main drain shall be true from manhole to manhole and any change in direction shall take place inside the manhole by the use of taper channels, straight or curved as necessary and not by the use of tapers or bend in the line drain outside the manhole.

### 4.0 MANHOLES

Will be designed according to the depth and the number of sewage line meeting at the points. These shall be constructed as under.

a. Excavate in any soil, make good and dispose of surplus spoil.

b. Foundations shall be 150 mm thick, as shown in drawings.

c. Bolsters around manhole covers shall be of 150 mm x 150 mm of CC 1:2:4.

d. Benchings shall be cement concrete (1:3:6) with main and branch channels formedtheir in raising 45 degrees from channel edges and all surfaces trowelled smooth.

e. Cover slabs shall be of stone or precast concrete bedded in cement mortar.

(1) Stone covers shall be 75mm thick of approved strong slab of self-faced stone.

(2) Cement concrete 1:2:4 reinforced with bars as shown in drawings with surfaces and edges finished fair.

f. Cover and frame will be bedded in mortar bolstered round with 150mm x 150mm cement concrete 1:2:4.

g. Mortar shall be cement mortar 1:3.

h. Walls shall be either of the following as ordered.

(1) Burnt brick work 230 mm thick in CM 1:3.

(2) Approved rubble stone 300 mm thick in CM 1:3.

(3) Solid concrete blocks 1:2:4, 200 mm thick in CM 1:3.

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(4) Poured cement concrete 1:3:6, 230 mm thick.

(5) R.C.C 1:2:4, 100 mm thick reinforced with deformed steel bars.

j. Internal faces of walls shall be hacked for plaster key, cleaned dubbed out with mortar and rendered not less than 13mm thick with CM 1:3.

k. If rock is encountered in excavation of the manholes, prior orders of the Engineer incharge will be obtained before starting excavation. Extra payment for rock will be excavation will be deducted at the average rate of ordinary and hard soil rates.

## 5.0 MANHOLES COVERS

Precast Plank covers shall be as specified and as shown in drawings

## 6.0 TESTING

a. All new drains, manholes, etc will be tested before haunching with concrete and before the trenches are filled in at the contractor‘s expense.

b. All drains are to be tested by filling with water having a head of not less than 0.6 m and not more than 1.8 m above the top of the lowest pipe in the length tobe tested.

c. Manholes and branch drains discharging into manholes will be tested independently. All vent pipes and soil pipes will be tested by a smoke test.

d. The contractor is to be responsible for any disturbance of the drains, etc, after they have passed the test satisfactory. After drains are laid an interval of at least 48 hrs must elapse before testing to allow sufficient time for the joints to set.

e. For smoke testing the smoke machine and necessary chemicals or smoke rockets to be provided by the contractor. The tests will be carried out in such a manner as the Engineer incharge will direct and to his satisfaction and at the contractor‘s expense.

## 7.0 WIRE GUARDS

To be of stout wire, galvanized after manufacture, dome or balloon pattern as ordered, to be fixed over outlets of down pipes or tops of ventilating pipes.

## 8.0 DAMAGES ETC

The contractor will be responsible for any disturbance / damage to the sewage lines evenafter the test within maintenance period.

## METHOD OF MEASUREMENTS

## 9.0 PIPE WORK GENERALLY SHALL BE MEASURED

Net overall length of pipes and fittings as fixed except where otherwise indicated.

## 10.0 MANHOLES

Internal plan area x height (as defined below).

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a. Uniform area on plan:-

Height = From invent to top of manhole cover.

b. With shaft of reduced area:-

(1) Chamber Height = From invent to junction of shaft with chamber internal plan area of chamber.

(2) Shaft Height = From junction of shaft with chamber or top of manhole cover. Internal plan area of shaft.

c. The internal area of circular manholes shall be the internal diameter squared. In calculating internal area of shafts, ignore any corbelling out.

## 11.0 CLARIFICATION OF RATES

The rates, interalia, include particularly.

a. Fixing complete in long or short lengths, including running joints in the length.
b. Making good surface disturbed.
c. Cutting hole in wall, and roof and making good.

***END OF SECTION***

# RAIN WATER / STORM DRAINAGE

## GENERAL

1.1 Submit pipe and fittings and have approved before starting installation. Pipe, and fittings to be new, manufactured domestically, and marked clearly with manufacturers' name, weight, and classification or working pressure.

1.2 Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

1.3 Provide seismic support and bracing of all piping systems in accordance with seismic details shown on drawings.

## PRODUCTS

### 2.1 MATERIAL

All rain water pipes & fitting are UPVC, gravity type. All pipes and fitting shall be assembled in strict accordance with manufacturers written instructions.

UPVC (Un-plasticised Polyvinyl Chloride) pipes confirming to British Standard Specifications No. BS4514 & BS5255 with rubber ring joints will be used for soil, waste, rain water and vent system.

Only UPVC molded fitting and specials will be used and no fabricated fitting will allowed.

All pipe work shall be completed as per specification laid in this section and as specified in the ―Pipe Work Installation‖.

### 2.2 INSTALLATION

All horizontal piping should be installed in practical alignment at a uniform downstream slope 1:40 for pipes 4" and smaller and 1:100 for large pipes. Piping should be installed in practical alignment and sloped up works continuously from the lowest connection with soil or waste piping to its termination in the atmosphere above the building roof.

All underground pipes should be laid on a firm natural bed of earth for its entire length, clean earth, sand or screened gravel should be placed under, around and above the piping to at least 1 ft above it, and compacted carefully. Thereafter excavated earth should not be allowed in trench as backfill material.

All horizontal piping should be provided with clean outs/plug as required for rodding. An accessible clean out should be provided at the base of the soil and waste stack.

All supports and hangers will be provided and installed as per recommendation of pipe manufacturer and approved by the Engineer Incharge.

The lubricant sealant as recommended by the pipe manufacturer will be used.

## 2.3 HANGERS

1. Seismic application: The use of C-clamps for hanging pipe is expressly prohibited on the project.

2. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

3. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

4. Provide concrete inserts, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

5. Attention is called to pipe spring isolation specified to be furnished by this Contractor.

6. Support all piping by adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following table.

7. Support each fitting, at intervals of not more than 5 feet, and at least at each joint.

8. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

## 2.4 CLEANING

1. The Contractor shall remove all silt and foreign matter from drains outlets and leave the whole in a clean workable condition.

2. It is the property Employer‘s responsibility to maintain the system components according to manufactures written recommendations.

## 2.5 TESTING

The Contractor shall submit the Engineer Incharge prior to the date of commencement of tests his proposed test procedure.

All testing shall be in accordance with the provision of applicable B.S. Code of practice.

The system shall be subjected to the water test prior to being covered and also tested for water tightness after back filling. A smoke test shall be performed to check the effectiveness of water seals of the system.

Any damage resulting from the test shall be repaired and or damage material replaced, all to the satisfaction of the Engineer Incharge. In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommended after the adjustments or repairs have been completed.

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## EXECUTION

3.1 Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

### 3.2 FIRE-RATED PARTITIONS

Provide permanent fire stop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible fire stopsystems. The fire stop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for upto 2hours fire rating.

Fire stop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume.

Fire stop system shall be installed in strict accordance with published U.L approved installation instructions.

Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed.

Submit U.L. approved installation drawing for each type of penetration prior to construction.

### 3.3 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Fire stopping is not requiredat non-rated partitions.

3.4 Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

3.5 Hang piping so equipment, flanges, and connections do not bear weight of piping.

3.6 Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

3.7 Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

3.8 Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

### 3.9 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.10 Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

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3.11 Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends fromforeign matter. Use temporary plugs or other approved methods of open end closure.

3.12 Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

3.13 Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

3.14 Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

3.15 Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.

### 3.16 GRADES AND ELEVATIONS

A. Uniformly grade storm drainage lines to elevations shown. If no elevations aregiven, pitch sewers not less than 1/8" per foot.

## STORM DRAINAGE

## GENERAL

### 4.1 DESCRIPTION

This section describes the requirements for storm drainage systems, including piping and all necessary accessories as designated in this section.

### 4.2 RELATED WORK

A. FIRESTOPPING: Penetrations in rated enclosures.

B. PAINTING: Preparation and finish painting and identification of piping systems.

C. COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports,Materials Identification.

D. PLUMBING INSULATION: Pipe Insulation.

### 4.3 SUBMITTALS

A. Submit in accordance with SHOP DRAWINGS, PRODUCT DATA, ANDSAMPLES.

B. Manufacturer's Literature and Data:

1. Piping
2. Roof Drains
3. Cleanouts
4. All items listed in Part 2 - Products

C. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

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## 4.4 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American National Standards Institute (ANSI).

C. American Society of Mechanical Engineers (ASME): (Copyrighted Society)

D. American Society for Testing and Materials (ASTM):

E. American Welding Society (AWS):

F. International Code Council (ICC):

G. Cast Iron Soil Pipe Institute (CISPI):

H. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

## PRODUCTS

## 5.1 STORM WATER DRAIN PIPING

A. Cast Iron Storm Pipe and Fittings:

1. Cast iron storm pipe and fittings shall be used for the following applications:

   a. Pipe buried in or in contact with earth.

   b. Extension of pipe to a distance of approximately 1500 mm (5 feet) outside of building walls.

   c. Interior storm piping above grade.

   d. All mechanical equipment rooms or other areas containing mechanical airhandling equipment.

2. The cast iron storm Pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI Standard 301, ASTM A-888, or ASTM A-74.

4. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM Standard C-564 or be installed with leak and oakum.

B. Copper Tube, (DWV): May be used for piping above ground.

1. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.

2. The Copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME 16.29.

3. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

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C. Polyvinyl Chloride (PVC)

1. Polyvinyl chloride storm sewer pipe and fittings are permitted for single story structuresexcept for mechanical equipment rooms and other areas containing air handling equipment or hot water generation equipment.

2. Polyvinyl chloride storm sewer pipe and fittings shall be schedule 40 solid core sewer piping conforming to ASTM D1785 and D 2665, Sewer and Drain Series, with ends for solvent cemented joints.

3. Polyvinyl chloride joints shall be solvent welded socket type using solvent cement conforming to ASTM D2564.

D. Roof drain piping in locations where the outdoor conditions are subject to freezing shall be insulated.

## 5.2 PUMPED DRAIN PIPING:

A. Pumped drain piping under 100 mm (4 inches) shall be copper tube conforming to ASTM B88, type K or L. For pumped drain piping 100 mm (4 inches) and above, galvanized steel conforming to A 53, seamless, schedule 40 may be used.

B. Pumped drain pipe fittings shall comply with the following:

1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22.

2. Unions shall be bronze, Mss SP-72, SP-110. Solder or braze joints.

3. Grooved fittings, 65 mm to 100 mm (2-1/2 to 4 inch) wrought copper ASTM A75 C12200, 125 to 150 mm (5 to 6 inch) bronze castings ASTM B584, CDA 844. Mechanical grooved couplings, ductile iron, ASTM A536 (Grade 65-45-12), malleable iron, ASTM A47 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with colored alkyd enamel.

C. Adapters shall be provided for joining screwed pipe to copper tubing.

D. The solder shall use a non-corrosive flux conforming to ASTM B32.

## 5.3 SPECIALTY PIPE FITTINGS

A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear erring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:

1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.

2. For PVC soil pipes, the sleeve material shall be elastomeric seal or PVC, conforming to ASTM F 477 or ASTM D5926.

3. For dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, orother material compatible with the pipe materials being joined.

B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 860 kPa (125 psig) at a minimum temperature of 82°C (180°F). The end connection shall be solder joint copper alloy and threaded ferrous.

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C. Dielectric flange insulating kits shall be of non conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.

D. The dielectric nipples shall be electroplated steel nipple comply with ASTM F 1545 with a pressure ratings of 2070 kPa (300 psig) at 107°C (225°F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

## 5.4 CLEANOUTS

A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged storm sewer line.

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts where shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 150 mm by 150 mm (6 inch by 6 inch) shall be provided at each wall cleanout.

D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

## 5.5 ROOF DRAINS AND CONNECTIONS

A. Roof Drains: Roof Drains (RD) shall be cast iron with clamping device for making watertight connection. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 300 mm (12 inches) in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.

1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 300 mm (12 inches) in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The Bottom section shall serve as roof drain during construction before insulation is installed.

2. Canopy Roofs: The roof drain shall have a beehive or dome shaped strainer with the integral

flange not larger than 200 mm (8 inches) in diameter. For an insulated roof, the roof drain shall be provided with an adjustable drainage collar, which can be raised or lowered to meet the required insulation heights, sump receiver and deck clamp. Bottom section shall serve as roof drain during construction before insulation is installed.

3. Promenade Decks: the roof drain shall be the same as for canopy roofs, except decks shall have flat, round, loose, non-slip, bronze grate set in square, non-slip, bronze frame.

4. Portico Roofs and Gutters: Roof drains shall be horizontal angle type drain with flat bottom and horizontal outlet at the same elevation as the pipe to which it is connected. Strainer shall be removable angle grate type.

5. Protective Roof Membrane Insulation Assembly: The roof drain shall have a perforated stainless steel extension filter, non puncturing clamp ring, large sump with extra wide roof flange and deck clamp.

   a. Non pedestrian Roofs: The roof drain shall have large polypropylene or aluminumlocking dome.

   b. Pedestrian Roof: The rood drain shall have a bronze promenade top 350 mm (14inches) square, set in square secured frame support collar.

6. Roof Drains, Overflow: Roof Drains identified as overflow drains shall have a 50 mm(2 inch) water dam integral to the drain body.

7. Roof drains in areas subject to freezing shall have heat tape and shall be insulated.

B. Expansion Joints: Expansions joints shall be heavy cast iron with cast brass or copper expansion sleeve having smooth bearing surface working freely against a packing ring held in place and under pressure of a bolted gland ring, forming a water and air tight flexible joint. Asbestos packing is prohibited.

C. Interior Downspouts: An expansion joint shall be provided, specified above, at top of run on straight, vertical runs of downspout piping 12 m (40 feet) long or more.

D. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

## 5.6 WATERPROOFING

A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fittingthat will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.

B. Walls: See detail shown on drawings.

## EXECUTION

## 6.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the International code and these specifications.

B. Branch piping shall be installed from the piping system and connect to all drains and outlets.

C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.

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D. All pipe runs shall be laid out to avoid interference with other work.

E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.

F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every1.22 m (4 feet) of pipe length.

G. The piping shall be installed free of sags and bends.

H. Seismic restraint shall be installed where required by code.

I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and 1/8 bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Buried storm drainage piping shall be laid beginning at the low point of each system. Pipingshall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer‘s written instruction for use of lubricants, cements, and other installation requirements.

K. Caste iron piping shall be installed according to CISPI‘s ―Cast Iron Soil Pipe and Fittings Handbook,‖ Chapter IV, ―Installation of Cast Iron Soil Pipe and Fittings‖.

L. Aboveground copper tubing shall be installed according to Copper Development Association‘s ―Copper Tube Handbook‖.

M. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.

## 6.2 JOINT CONSTRUCTION

A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI‘s ―Cast Iron Soil Pipe and Fittings Handbook‖ for compression joints.

B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI‘s ―Cast Iron Soil Pipe and Fittings Handbook‖ for lead and oakum calked joints.

C. Hubless, cast iron piping shall be joined in accordance with CISPI‘s ―Cast Iron Soil Pipe and Fittings Handbook‖ for hubless piping coupling joints.

D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service.

2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

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E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

F. for PVC piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F402. The joint shall conform to ASTM D2855 and ASTM D2665 appendixes.

## 6.3 SPECIALTY PIPE FITTINGS

A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

## 6.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES:

A. All piping shall be supported according to the International plumbing code, COMMON WORK RESULTS FOR PLUMBING, and these specifications.

B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 1500 mm (60 inches) with 10 mm (3/8 inch)rod.
2. NPS 3 (DN 80): 1500 mm (60 inches) with 13 mm (1/2 inch) rod.
3. NPS 4 to NPS 5 (DN 100 to DN 125): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.
4. NPS 6 to NPS 8 (DN 150 to DN 200): 1500 mm (60 inches) with 19 mm (3/4 inch) rod.
5. NPS 10 to NPS 12 (DN 250 to DN 300): 1500 mm (60 inches) with 22 mm (7/8 inch)rod.

E. The maximum support spacing for horizontal plastic shall be 1.22 m (4 feet).

F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 m (15 feet).

G. In addition to the requirements in COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates shall have the following characteristics:

1. Solid or split unplated cast iron.
2. All plates shall be provided with set screws.
3. Height adjustable clevis type pipe hangers.
4. Adjustable Floor Rests and Base Flanges shall be steel.

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5. Hanger Rods shall be low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.

6. Riser Clamps shall be malleable iron or steel.

7. Roller shall be cast iron.

8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gage steel. The shield shall be sized forthe insulation.

H. Miscellaneous Materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

I. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

J. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.

2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified JOINT SEALANTS.

K. Piping shall conform to the following:

1. Storm Water Drain and Vent Drain to main stacks:

| Pipe Size | Minimum Pitch |
|---|---|
| 80 mm (3 inches) and smaller | 2% |
| 100 mm (4 inches) (4 inches) and larger | 1% |

## 6.5 TESTS

A. Storm sewer system shall be tested either in its entirety or in sections.

B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.

1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.

2. For an air test, an air pressure of 35 kPa (5 psi) gage shall be maintained for at least15 minutes without leakage. A force pump and mercury column gage shall be used for the test.

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3. Final Tests: Either one of the following tests may be used.

   a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1.3 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.

   b. Peppermint Test: Introduce 06 liters (2 ounces) of peppermint into each line or stack.

***END OF SECTION***

# DOMESTIC WATER HEATERS / GEYSERS (NATURAL GAS FIRED)

## GENERAL

### 1.01 RELATED DOCUMENTS

Drawings and general provisions of the Contract.

Specifications throughout of the Project Manual are directly applicable.

### 1.02 SUMMARY

This section covers providing all labor and materials for the complete first class installation of storage tank type gas fired domestic water heaters indicated and scheduled on Construction Drawings complete with all controls, piping, valves, accessories, testing, start-up and other normal parts that make the systems complete, operable and acceptable to the authorities having jurisdiction.

### 1.03 REFERENCE STANDARDS

The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

2009 Edition of the International Plumbing Code. 2009 Edition of the International Fuel Gas Code.

### 1.04 QUALITY ASSURANCE

Perform Work in accordance with State of Texas Department of Health Standards.

Water heaters shall be manufactured by a company that has achieved certification to the ISO 9001 International Quality System.

Provide equipment with manufacturer's name, model number, and rating / capacity permanently identified.

Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:

1. National Sanitation Foundation.
2. American Society of Mechanical Engineers (ASME stamped - 225 psi testpressure)
3. National Board Registered for 150 psi working pressure.
4. National Electrical Manufacturers' Association.

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5. Underwriters Laboratories. UL / ULC listed to safety standard UL 795 "Commercial-Industrial Gas Heating Equipment". UL listed for use with CPVC venting material.
6. ASHRAE 90.1 compliant for thermal efficiency, and standby heat and electrical loss.
7. Factory Mutual compliant.

## 1.05 SUBMITTALS

Product Data:

1. Include dimension Drawings of water heaters indicating piping, components and required connections.
2. Manufacturer's data sheets and Installation Instructions.
3. Provide wiring diagrams, electrical characteristics and connection requirements
4. Provide complete copy of all warranties and service policies, including allexclusions and conditions, as part of the submittal package.

Record Documents:

1. Provide full written description of manufacturer‘s warranty.
2. Provide emissions levels certification by independent agency.
3. Provide at least two copies of equipment startup report.
4. Shop Drawings:

a. Include heater dimensions, capacities, location and size of tappings, drains, anchors, lifting points and attachments.

b. Provide manufacturer‘s recommended piping arrangement diagram.

Operation and Maintenance Data:

Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

## 1.06 DELIVERY, STORAGE AND HANDLING

Provide temporary inlet and outlet caps. Maintain caps in place until installation.

Do not operate the hot water heater for any reason until the factory startup service has been completed.

## 1.07 WARRANTY

The burner and all heater parts shall have a one-year cost-free service policy warranty. Storage tank, heating surfaces, and combustion chamber shall have a ten-year warranty covering manufacturing or material defects, leaks, and/or the production of rusty water. Tank and heating surfaces shall have a three-year warranty against failure due to scale buildup with no provisions for periodic cleaning. Initiation and/or continuation of warranty coverage shall not be dependent upon annual inspections, regular replacement of anoderods, or water chemistry.

## PRODUCTS

### 2.01 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

### 2.02 STORAGE TANK TYPE DOMESTIC HOT WATER HEATER (NATURAL GAS FIRED)

A. Furnish and install condensing, low NOx, natural gas-fired domestic water heaters with dimensions, capacities and electrical characteristics as scheduled on the Construction Drawings and as outlined herein. This Specification describes minimum quality and performance requirements. Variations of system components by the individual referenced manufacturers are acceptable for installation in this project provided they meet or exceed all of the requirements scheduled on Contract Drawings, indicated herein and fit properly in the space provided.

B. The water heater shall be a vertical fire tube design that is constructed and stamped in accordance with the ASME code. Both the storage and heating sections of the water heater shall be National Board Registered for a working pressure of 150 psi and shall be pressure tested at 1-1/2 times working pressure. The fireside of the heating surfaces shall be of boiler-grade steel. The waterside of the heating tubes shall be sealed in copper. The heating tubes shall be rolled, beaded, and seal welded into the tube sheets. The combustion side of the tube sheet shall be insulated by a layer of ceramic fiber that shall protect the tube sheet from both thermal stresses and failure that can result from the accumulation of scale and precipitants.

C. The tank shall be a plated with electroless nickel. Plating shall occur after the pressure vessel is completely fabricated and all welding is completed. The electroless nickel plating shall be a high-phosphorus (10%) and nonporous composition suitable for submersion service (ASTM B733 standard may be used as a guideline). The finished lining shall not require sacrificial anode rods. For additional protection against galvanic corrosion, which may occur within the potable water system, the electroless nickel plating may have a high-dielectric-strength polymer overcoat.

D. The tank shall be insulated and jacketed with steel panels finished with an industrial quality coating.

E. Combustion shall be provided by an induced-draft power burner with a gas train meeting Factory Mutual requirements for the scheduled input.

F. Water heater shall be a category IV, condensing appliance, UL listed for use with CPVCvent or AL 29-4C stainless steel vent. Burner shall be configured to accept combustion air as indicated on Construction Drawings and factory equipped for direct venting and direct inlet air for up to 500 equivalent feet. Water heater shall operate with a minimumgas pressure of 4-½ inches water column.

G. The water heater shall operate at a minimum of 94% thermal efficiency when tested to ANSI Z21.10.3. The water heater shall comply with paragraph 7.2.4.4, the thermal efficiency, the standby loss, and all other requirements of ASHRAE 90.1-1999.

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H. NOx emissions shall not exceed 30 ppm when corrected to 3% Oxygen (for inputs greater than 399,000 Btu). NOx emissions shall not exceed 55 ppm when corrected to 3% Oxygen (for 399,000 Btu input).

I. The storage and heating sections shall be completely factory packaged on a singles kid, requiring only job Site hookup to utilities, venting, and water inlet and outlet piping.

J. As a minimum, each heater shall be equipped with the following components:

1. Dial temperature and pressure gauges.
2. Two immersion operating thermostats.
3. Tank circulator with intermittent pump operation.
4. Handhole tank cleanout.
5. Drain valve.
6. Induced draft blower.
7. Remote on/off terminals.

K. As a minimum, each heater shall be equipped with the following safety controls:

1. Solid-state flame safeguard with pre-purge, programmable post-purge, and flame status indicating lights.
2. Immersion temperature limiting device.
3. Stack temperature limiting device.
4. ASME rated temperature and pressure relief valve.
5. Electronic low water cutoff.
6. Manual-reset, immersion temperature limiting device.

## EXECUTION

### 3.01 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

All installation shall be in accordance with manufacturer‘s published recommendations.

Installation shall conform to all local, state, and national codes.

Install the water heaters, piping, vents and accessories in accordance with the manufacturer‘s published installation instructions.

Furnish all supports required by the equipment included in this Contract. Provide a 4" thick,

reinforced concrete housekeeping pad beneath heaters.

Furnish and install all necessary valves, traps, gauges, strainers, unions, etc. to facilitateproper functioning and servicing of equipment.

Install a line size shutoff valve in cold water inlet and hot water outlet close to eachheater.

Provide a temperature gauge in the domestic hot water piping within five feet of outlet to each heater, upstream of all shut-off valves. Size and locate gauges to be easily readable from a standing position.

Provide dielectric isolation device where copper lines connect to ferrous lines or equipment, such as dielectric coupling or dielectric flange fitting.

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Route condensate to a vented receiver.

Pipe relief valve discharge and all equipment drains indirectly to appropriate floor drain. Set the operating and safety controls.

Set thermostats on domestic water heaters to deliver maximum water temperature asindicated on Contract Drawings.

Furnish and install an expansion tank on cold water supply to heater. Locate tank as close to water heater as possible between water heater and all check valves or backflow preventers. Expansion tank capacity shall be as scheduled on Contract Drawings. Install expansion tank in accordance with manufacture's recommendations.

## 3.02 STARTUP

Startup shall be performed by factory trained and authorized personnel. The factory representative shall also provide a technical and practical operation and maintenance training seminar including a hands-on operation and maintenance demonstration, and classroom presentation with handouts and visual aids, for no less than three physical plant personnel.

***END OF SECTION***

# ELECTRIC DOMESTIC WATER HEATERS / GEYSERS

## GENERAL

### 1.1 DESCRIPTION:

This section describes the requirements for installing a complete electric domestic water heater system ready for operation including the water heaters, thermometers, and all necessary accessories, connections, and equipment.

### 1.2 RELATED WORK:

A. PAINTING: Preparation and finish painting.

B. COMMON WORK RESULTS FOR PLUMBING.

C. DOMESTIC WATER PUMPS: Circulating Pumps.

D. Heater Insulation.

E. METERS AND GAGES FOR PLUMBING PIPING, GENERAL-DUTY VALVES FOR PLUMBING PIPING, FACILITY WATER DISTRIBUTION: Piping, Fittings, Valves and Gages.

F. SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic restraint for Equipment.

### 1.3 QUALITY ASSURANCE:

A. Comply with American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE) for efficiency performance:

1. ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings, ‖for commercial water heaters.‖

B. Electrical components, devices and accessories shall be listed and labeled B asdefined in NFPA 70 by a qualified testing agency, and marked for intended location and application.

C. ASME code construction shall be a vessel fabricated in compliance with the ASME boiler and Pressure Vessel Code.

D. Fabricate and label equipment components that will be in contract with potable water to comply with NSF 61, ¯Drinking Water System Components – Health Effects‖.

E. The electric domestic water heater shall conform to Seismic restraint requirements, withstanding Seismic movement without separation of any parts from the equipment when subjected to a Seismic event.

### 1.4 SUBMITTALS:

A. Submit manufacturer's literature and data pertaining to the water heater in properly bound

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package, in accordance with contract SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Include the following as a minimum:

1. Water Heaters.
2. Pressure and Temperature Relief Valves.
3. Thermometers.
4. Pressure Gages.
5. Vacuum Breakers.

B. For each electric domestic hot water heater type and size, the following characteristics shall be submitted:

1. Rated Capacities.
2. Operating characteristics.
3. Electrical characteristics.
4. Furnished specialties and accessories.
5. A form U-1 or other documentation stating compliance with the ASME Boiler and Pressure Vessel code.

C. Shop drawings shall include wiring diagrams for power, signal and control functions.

D. Seismic qualification certificates shall be submitted that details equipment anchorage components, identifies equipment center of gravity with mounting and anchorage provisions, and whether the seismic qualification certificate is based on an actual test or calculations.

E. The domestic water heater shall be certified and labeled by a testing agency.

## 1.5 AS-BUILT DOCUMENTATION

A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shallbe prepared by a computer software program complying with Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C 794d). The manufacturer or vendor of the software used to prepare the electronic documentation shall have a Voluntary Product Accessibility Template made available for review and included as part of the Operations and Maintenance Manual or closeout documentation. All available accessibility functions listed in the Voluntary Accessibility Template shall be enabled in the prepared electronic files. As Adobe Acrobat is a common industry format for such documentation, following the document, "Creating Accessible Adobe PDF files, A Guide for Document Authors" that is maintained and made available byAdobe free of charge is recommended.‖

B. Four sets of manufacturer‘s literature and data updated to include submittal review comments and any equipment substitutions.

C. Four sets of operation and maintenance data updated to include submittal review comments shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special

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systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the Employer will be required to employ shall be inserted into the As-Built documentation.

## PRODUCTS

### 2.1 ELECTRIC DOMESTIC WATER HEATERS:

A. The tank construction shall be steel shell, with a inner tank liner complying with NSF 61 for barrier materials for potable water. The inner liner shall be extended into the tappings. The vessel shall be ASME Boiler and Pressure Vessel Code (BPVC), section VIII, fabricated with a pressure rating of 1035 kPa (150 psig).

B. Tapping (openings) shall be Factory fabricated of materials compatible with the tank and in accordance with appropriate ASME standards B1.20.1 for piping connections, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required. Tappings shall comply with the following:

1. 50 mm or DN50 (2 inch) and smaller: Threaded ends according to ASME B1.20.1.

2. 65 mm or DN65 (2 1/2-inch) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B 16.24.

C. Tank insulation shall comply with ASHRAE 90.1.

D. For domestic hot water heater sizes greater than 9 KW, the heating element shall be arranged in multiples of three elements. For heaters less than 9 KW, the heater elements shall be arranged in/single/double/elements.

E. The domestic hot water heaters shall have screw in or bolt in immersion type, thermostatically adjustable. Set thermostat for maximum water temperature of 55°C (130°F). The electrical characteristics are scheduled on the drawings.

F. Combination Pressure and Temperature Relief Valves shall be ASME rated and stamped for combination temperature and pressure relief valves. One or more relief valves with total relieving capacity at least as great as the heat input shall be included. The pressure setting shall be less than the domestic water heater working pressure rating.

G. The anode rod shall be replaceable magnesium.

H. The drain valve shall be corrosion resistant metal complying with ASSE 1005.

### 2.2 DOMESTIC HOT WATER COMPRESSION TANKS

A. A steel pressure rated tank constructed with welded joints and factory installed butyl rubber diaphragm shall be installed as scheduled. The air pre charge shall be set to minimum system operating pressure at tank.

B. The tappings shall be factory fabricated steel, welded to the tank and include ASME B1.20.1 pipe thread.

C. The interior finish shall comply with NSF 61 barrier materials for potable water tanklinings and the liner shall extend into and through the tank fittings and outlets.

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D. The air charging valve shall be factory installed.

## 2.3 ELEVATED ELECTRIC WATER HEATER DRAIN PAN

A. A stainless steel drain pan shall be provided that is large enough to contain the volume of the heater. The drain pan shall include a drain outlet not less than 20 millimeter or DN 20 (NPS 3/4‖) with ASME B1.20.7 garden hose threads.

## 2.4 HEAT TRAPS

A. Heat traps shall be installed in accordance with ASHRAE 90.1, latest edition.

## 2.5 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVES

A. The combination temperature and pressure relief valves shall be ASME rated and stamped and include a relieving capacity at least as great as the heat input and include a pressure setting less than the water heater‘s working pressure rating.

## 2.6 THERMOMETERS:

The thermometers shall be straight stem, iron case, red reflecting mercury thermometer or red liquid-filled thermometers, approximately 175 mm (7 inches) high, 4 to 115°C (40 to 240°F).

# EXECUTION

## 3.1 INSTALLATION:

A. Water heaters shall be installed on concrete bases unless elevated above the floor.Refer to Specification CAST-IN-PLACE CONCRETE and COMMON WORK RESULTS FOR PLUMBING.

B. The water heaters shall be installed level and plumb and securely anchored.

C. The water heaters shall be installed and connected in accordance with manufacturer‘s written instructions.

D. All pressure and temperature relief valves discharge shall be piped to nearby floordrains.

E. Thermometers shall be installed on the water heater inlet and outlet piping.

F. The thermostatic control shall be set for a maximum setting of 54 degrees C (130 degrees F).

G. Shutoff valves shall be installed on the domestic water supply piping to the waterheater and on the domestic hot water outlet piping.

H. All manufacturers‘s required clearances shall be maintained.

I. The electric domestic water heaters shall be installed with seismic restraintdevices.

J. A combination temperature and pressure relief valve shall be installed at the top portion of the storage tank. The sensing element shall extend into the tank. The relief valve outlet drain piping shall discharge by positive air gap into a floor drain.

K. Piping type heat traps shall be installed on the inlet and outlet piping of the electric domestic hot water heater storage tanks.

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L. Water heater drain piping shall be installed as indirect waste to spill by positive air gap into open drains or over floor drains. Hose end drain valves shall be installed at low points in water piping for electric domestic hot water heaters without integral drains.

### 3.2 LEAKAGE TEST:

Before piping connections are made, water heaters shall be tested with hydrostatic pressure of 1375 kPa (200 psi) and 1654 kPa (240 psi) for a unit with a MAWP of 1103kPa (160 psi). Any domestic water heater leaking water shall be replaced with a new unitat no additional cost to the Employer.

### 3.3 PERFORMANCE TEST:

All of the remote water outlets shall have a minimum of 49°C (120°F) and a maximum of 54°C (130°F) water flow at all times. If necessary, make all corrections to balance the return water system or reset the thermostat to make the system comply with design requirements.

***END OF SECTION***

# SUMP PUMPS

## GENERAL

**1.1** DESCRIPTION

A. Sump pumps. See Drawings for pump capacity and head.

**1.2** RELATED WORK

A. COMMON WORK RESULTS FOR PLUMBING.

B. GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

C. COMMISSIONING OF PLUMBING SYSTEMS.

Requirements for commissioning, systems readiness checklist, and training.

D. LOW-VOLTAGE MOTOR STARTERS.

**1.3** SUBMITTALS

A. Submit in accordance with the contract or as directed by the Engineer Incharge, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's Literature and Data:

1. Pump:
   a. Manufacturer and model
   b. Operating speed
   c. Capacity
   d. Characteristic performance curves

2. Motor:
   a. Manufacturer, frame and type
   b. Speed
   c. Current Characteristics and W (HP)
   d. Efficiency

C. Certified copies of all the factory and construction site test data sheets and reports.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable parts:

1. Include complete list which indicates all components of the system.

2. Include complete diagrams of the internal wiring for each item of equipment.

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements COMMISSIONING OF PLUMBING SYSTEMS.

PRODUCTS

**2.1 SUMP PUMP**

A. Centrifugal, vertical, submersible pump and motor, designed for 60 82 degrees C (140 180 degrees F) maximum water service. Driver shall be electric motor. Support shall be rigid type. Provide perforated, suction strainer. Systems may include one, two, or more pumps with alternator as required by: Contract Documents Pump Pumps shall be capable of continuous duty cycle.

1. Pump housings may be cast iron, bronze, aluminum, plastic or stainless steel. Cast iron and aluminum housings for submersible pumps shall be epoxy coated.

B. Impeller: Brass, bronze or cast iron.

C. Shaft: Stainless steel or other approved corrosion-resisting metal.

D. Bearings: As required to hold shaft alignment, anti-friction type for thrust permanently lubricated.

.

E. Motor: Maximum 40 degrees C (104 degrees F) ambient temperature rise above the maximum fluid temperature being pumped, drip-proof completely enclosed , voltage and phase as shown in schedule on Electrical drawings. Size the motor capacity to operate pump without overloading the motor at any point on the pump curve. GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

F. Starting Switch: Manually-operated, tumbler type, as specified in LOW-VOLTAGE MOTOR STARTERS.

G. Automatic Control and Level Alarm: Furnish a control panel in a Nema 1 enclosure for indoors or in a Nema 4X enclosure for outdoors. The controls shall be suitable for operation with the electrical characteristics listed on the Electrical drawings. The control panel shall have a level control system with switches to start and stop pumps automatically, and to activate a high water alarm. The level control system will include sensors in the sump that detect the level of the liquid. The sensors may be float type switches, ultrasonic level sensors, transducers, or other appropriate equipment. The high water alarm shall have a red beacon light at the control panel and a buzzer, horn, or bell. The alarm shall have a silencing switch. Provide auxiliary contacts for remote alarming to the Energy Control Center and BAC net compatible open-protocol type interface to DDC Controls System.
1.The circuitry of the control panel shall include:

a. Power switch to turn on/off the automatic control mechanism

b. HOA switches to manually override automatic control mechanism

c. Run lights to indicate when pumps are powered up

a. Level status lights to indicate when water in sump has reached the predetermined on/off and alarm levels

b. Magnetic motor contactors

c. Disconnect/breaker for each pump

d. Automatic motor overload protection

2. Sensors that detect the level of water in the sump shall be so arranged as to allow the accumulation of enough volume of liquid below the normal on level that the pump will run for a minimum cycle time as recommended by the pump manufacturer. Sensors shall be located to activate the alarm adequately before the water level rises to the inlet pipe.

3. Provide two separate power supplies to the control panel, one for the control/alarm circuitry and one for power to the pump motors. Each power supply is to be fed from its own breaker so that if a pump overload trips a breaker, the alarm system will still function. Each power supply is to be wired in its own conduit.

4. Wiring from the sump to the control panel shall have separate conduits for the pump power and for the sensor switches. All conduits are to be sealed at the basin and at the control panel to prevent the intrusion of moisture and of flammable and/or corrosivegases.

H. Sump: Furnish cast iron or fiberglass basin with gas tight covers. Cover shall have 280 mm by 380 mm (11-inch by 15-inch) manhole with bolted cover, vent connection, openingsfor pumps and controls. Sump shall be sized to allow an adequate volume of water to accumulate for a minimum one minute cycle of pump operation.

I. Provide a check and ball valve in the discharge of each pump.

J. Removal/Disconnect System: In a system utilizing a submersible pump, where sump depth, pump size, or other conditions make removal of the pump unusually difficult or unsafe, a removal/disconnect system shall be provided. The system will consist of a discharge fitting mounted on vertical guide rails attached to the sump. The pump shall be fitted with an adapter fitting that easily connects to/disconnects from the discharge fitting as the pump is raised from or lowered into the sump. The discharge piping will connect to the discharge fitting so that it is not necessary to disconnect any piping in order to remove the pump. Where the sump depth is greater than five feet or other conditions exist to make the removal of the pump difficult or hazardous, the system shall include a rail guided quick disconnect apparatus to allow the pump to be pulled up out of the sump without workers entering the sump and without disconnecting the piping.

EXECUTION

## 3.1 STARTUP AND TESTING

A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. The tests shall include system capacity and all control and alarm functions.

C. When any defects are detected, correct defects and repeat test.

D. An agent of the manufacturer will observe startup and contractor testing of selected equipment. The Contractor will coordinate the startup and testing schedules with the Engineer Incharge and Agent, with a minimum of 7 days prior notice.

## 3.2 COMMISSIONING

A. Provide commissioning documentation accordance with the requirements of the Contracts COMMISSIONING OF PLUMBING SYSTEMS for all inspection, startup, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. COMMISSIONING OF PLUMBING SYSTEMS and related sections for contractor responsibilities for system commissioning.

## 3.3 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for four hours to instruct Employer Personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of the Contract.

***END OF SECTION***

# GREASE TRAPS

## GENERAL

### 1.01 SCOPE

Grease traps are required wherever wastewater sources contain animal and vegetablederived grease products.

### 1.02 SUBMITTALS

Submit shop drawings and manufacturer's literature to the Engineer Incharge for approval in accordance with the Contract - Submittals.

## PRODUCTS

### 2.01 MATERIALS

A. Grease traps shall be manufactured in accordance with ASTM C1613 - Standard Specification for Precast Concrete Grease Interceptor Tanks.

B. All grease traps shall be externally located, RCC units designed specifically for removing FOG (fat, oil, grease) from wastewater.

C. Use a precast Plank as a man-hole cover.

## EXECUTION

### 3.01 DESIGN

A. Grease traps are to be designed for peak flow and sized based on required retention time. Retention time shall be based on the manufacturer‘s recommendation for operational discharge of less than 200 mg/L of FOG during peak flows.

B. Grease traps shall be designed and certified to operate efficiently at their maximum flow rate in GPM, and retain a minimum of twice its rated GPM inpounds of grease.

C. All design calculations and system designs shall be submitted to EngineerIncharge for review and approval.

D. Grease traps shall be sized in accordance with Standard PDI-G101 from the Plumbing and Draining Institute.

## 3.02 DELIVERY AND STORAGE

A. Inspect materials delivered to site for damage; unload and store with minimum handling.

B. Store materials on-site within enclosures or under protective coatings to protect against inclement weather and direct sunlight.

## 3.03 INSTALLATION

A. Grease traps shall be installed as shown on the Drawings and in strict accordance with the manufacturer's recommendations.

B. Grease traps shall not be located under pavement but shall be located within five feet of a paved vehicle access for cleaning and inspection, whenever possible.

C. Only waste from grease producing sources shall flow through the grease trap. All grease traps shall be located upstream of the location where human waste enters the service line. Sanitary wastes and other wastes shall flow through a separate lateral and connect to the receiving main.

## 3.04 QUALITY ASSURANCE AND TESTING

A. The grease trap shall be fabricated, inspected, and tested for leakage before shipment from the factory as a completely assembled system ready for installation.

B. Conduct pressure and leakage tests as required by the contract or as directed by the Engineer Incharge.

***END OF SECTION***

# GAS PIPING

## 1.01 SCOPE

This section shall govern the laying, installation of gas piping system, complete in all respect, in or in connection with a building, structure or within the property lines of premises

Piping systems requirements shall include design, materials, components, fabrications, assembly, installation, testing, inspection, operation, and maintenance.

## 1.02 SUBMITTALS

**A. Product Data:** For each type of the following:

1. Piping specialties.
2. Valves: Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Indicate pressure ratings and capacities.
4. Service meters. Indicate [pressure ratings and] capacities. Include [bypass fittings]

**Shop Drawings:** For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of thesame to building structure. Detail location of anchors, alignment guides, and expansion joints and loops, mounting, supports, and valve locations.

## 1.03 GENERAL

Coverage of piping systems shall extend from the point of delivery to the appliance connections. The point of delivery shall be the outlet of the meter.

Gas piping systems shall be of such size and so installed as to provide a supply of gas to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance

Underground piping systems shall be installed with a cover not less than 12 inches. Where external damage to the pipe or tubing from external forces is likely to result, the cover shall be not less than 18 inches. Where a cover not less than 12 inches cannot be provided, the pipe shall be installed in conduit or shielded.

## 1.04 MATERIALS

All Gas pipes shall be seamless galvanized steel pipes, conforming to ASTM A500.Indoor,

Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.

All piping systems shall be installed in accordance with NFPA 31

End Connections: Threaded or butt welding to match pipe.

Gasket Materials: ASME B16.20, metallic, flat, asbestos free, and spiral-wound metal gaskets.

Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy adhesive

Joint Cover Kits: Epoxy paint and/or adhesive.

Joining Materials: Joint Compound and Tape suitable for natural gas

Fittings used with steel or wrought-iron pipe shall be steel, copper alloy, malleable iron, or cast-iron.

## 1.05 INSTALLATION

Gas pipe system will be installed through registered SNGPL contractors on the basis of design drawings approved by SNGPL and the following general requirements.

- Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- Close equipment shutoff valves before turning off natural gas to premises or piping section.
- Comply with NFPA 54 requirements for installation and purging of piping and prevention of accidental ignition
- Locate valves for easy access
- Install piping free of sags and bends.
- Install fittings for changes in direction and branch connections
- Install manual gas shutoff valve for each gas appliance
- Provide clamps and hangers to support pipes at least at every 6 feet and as per NFPA 54:Table 7.2.5.2
- The contractor shall prepare and submit a schedule of gas appliances in the building for onward submission to SNGPL. Gas demand of appliance in British Thermal Unit (BTU) ¯The quantity of heat required to raise the temperature of one pound of fresh water one degree Fahrenheit‖ shall be listed against each appliance

## 1.06 INSPECTION

Inspection Notification

Upon completion of the installation, alteration, or repair of gas piping, and prior to the use thereof, SNGPL shall be notified that such gas piping is ready for inspection.

Excavation

Excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. Where such piping is covered or concealed before such approval, it shall be exposed upon the direction of SNGPL.

Type of Inspections

SNGPL shall make the following inspections and either shall approve that portion of the work as completed or shall notify the permit holder wherein the same fails to be in accordance with this code.

Rough Piping Inspection

This inspection shall be made after gas piping authorized by the permit has been installed and before such piping has been covered or concealed or fixture or appliance has been attached thereto. This inspection shall include a determination that the gas piping size, material, and installation meet the requirements of this specifications.

Final Piping Inspection

This inspection shall be made after piping authorized by the permit has been installed and after portions thereof that are to be covered or concealed are so concealed and before fixture, appliance, or shutoff valve has been attached thereto. This inspection shall comply with Section 1213.1. Test gauges used in conducting tests shall be in accordance with Section 318.0.

Inspection Certificate

When after final piping inspection, testing and commissioning, the installation is found to be in accordance with design and SNGPL requirements; a Completion report and Certificate of Inspection shall be issued.

## 1.07 PERFORMANCE REQUIREMENTS

Minimum Operating-Pressure shall be as specified by SNGPL or as follows

- Piping and Valves: 15 psi minimum unless otherwise indicated.
- Service Regulators: 10 psi minimum unless otherwise indicated.
- Minimum Operating Pressure of Service Meter: 15 psi
- Natural-Gas System Pressure within Buildings: More than 2 psig but not morethan 5 psig

## 1.08 RESPONSIBILITY

The Employer of the building has the responsibility to maintain gas piping and equipment inside the building in a safe and operating condition. Any significant changes in connected loads shall be reported to SNGC immediately.

## 1.09 DELIVERY, STORAGE, AND HANDLING

a. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

b. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

c. Protect stored pipes and valves from direct sunlight.

## 1.10 QUALITY ASSURANCE AND TESTING

Prior to acceptance and initial operation, piping installations shall be visually inspected and pressure-tested to determine that the materials, design, fabrication, and installation practices are in accordance with the requirements.

After installation of complete gas piping system, it will be tested at a pressure of 10 PSI for 15 minutes and checked for leakages from end to end.

The test medium shall be air, nitrogen, carbon dioxide, or an inert gas. OXYGEN SHALL NEVER BE USED

Pipe joints, including welds, shall be left exposed for examination during the test.

Testing of piping systems shall be performed in a manner that protects the safety of employees and the public during the test.

Natural-gas piping will be considered defective if it does not pass tests and inspections.

Where leakage or other defects are located, the affected portion of the piping systemshall be repaired or replaced and retested

## 1.11 CONNECTION TO UTILITIES:

The Contractor shall be responsible, to make application/notices, in all respects, to the utility company/corporation/authority/board/or any other body having jurisdiction, for obtaining connection from the natural gas mains required for the works. The Contractor shall further pursue and liase with the body having jurisdiction in providing connection permission, make all necessary payments, obtain necessary permission, and obtain the gas connection. The extent of work specified represents the minimum requirements and the extent of the work shall be extended as requiredto include, at no increase in cost to the Employer, the compliance and fulfillment of the requirements of the local power supply authority for an installation of this type. Official fees against challan shall be paid by the Employer at actual.

***END OF SECTION***

# SOAK PIT

## 1.01 PERCOLATION TEST:

Prior to construction of the Soak Pit, this Contractor shall be required to perform a percolation test to determine the absorption capacity of the soil. The test shall be conducted as follows:

a. A test pit shall be dug approximately 5 feet in diameter and to such a depthas to reach porous soil, but not less than 8 feet
b. In the bottom of this pit a 12‖ square and 12‖ deep hole shall be made.
c. The hole shall be filled with water for a depth of 7 inch. For pre-watering purposes, the water level shall be allowed to drop to 6 inches, before time of recording is started.
d. After the level of the water has dropped to 6 inches, the time required for the water level to drop every inch shall be recorded, till the level is 2 inch.
e. The hole shall again be refilled and the test repeated.
f. After the test, the thickness of the porous soil below the point of percolation shall be determined by using a soil auger, and the depth indicated in the test report.
g. If sub-soil water is encountered, the test report shall indicate the level of the same.

The final number and size of the soakage pits shall be provided to the Contractor after the result of the percolation test are received.

## 1.02 CONSTRUCTION:

**Size:** The soakage Pit shall be constructed as shown on the drawing. The size and quantity of the soakage pits shall be finally determined after receipt of the percolation test results by the Engineer Incharges. Soakage pit shall not penetrate ground water table.

**Excavation:** The excavation of the soakage pit shall be greater in diameter than theoutside diameter of the vertical side walls to allow for the footing. To prevent soil collapse, excavation of the soil at an angle may be required.

**Annular Space:** The annular space between the outside of the vertical walls and the excavation shall be filled with broken stone, coarse gravel or other suitable material.

**Bottom:** The soak Pit bottom shall be open, with an outer ring to support the side walls.

**Side Walls:** The side walls shall be made of brick up as shown in drawings

**Top:** The Soak Pit top shall be of 100mm thick 1:2:4 RCC and shall be provided with one 24‖ x 24‖ RCC Cover with C.I. frame, as approved by the Engineer Incharge.

**Reinforcement:** Reinforcement to construct a structurally sound structure shall be provided as per good engineering standard.

## 1.03 PAYMENT:

Payment shall be made per unit rate for the complete soak well as specified in the BOQ, and shall be deemed to include the cost of the percolation test, excavation, backfilling, all masonry & concrete works, soak-pit fillers, manhole cover and other works required to complete the soak well in all respects.

***END OF SECTION***

# TUBE WELL

## 1.01 SCOPE OF WORK:

The Specifications are for the drilling of tubewells equipped with pumps. The Contractor shall provide all labor, transport, plant, tools, equipment and materials and appurtenances, and shall perform all works necessary; to satisfaction of Engineer Incharge, including but not limited to the following:

a. Construct and complete successfully drilled tubewells including lowering of tubewell assembly with PVC casing and Screen and end cap,
b. gravel pack at appropriate intervals and back fill, close near surface watertable aquifer,
c. cleaning and development of tubewells,
d. pump test for 3 hours,
e. chlorinate tubewell,
f. Construct the concrete structure for the tube well
g. install the pumping system
h. Proceed to water security approval by an independent /authorized lab

Refer to drawings and bills of quantities for complementary information.

Please note, that all works, all supplementary materials, linings, accessories, preparation of the surfaces, fixing elements, any types of joints and any other items in connection with the Works not referred to or described in the Bill of Quantities but deemed necessary, should be executed according to the technical card of the material manufacturer and should be carried out in accordance with the Design Drawings, Specifications should be included in the price.

## 1.02 TUBE WELL CONSTRUCTION:

A typical tube well section / well section are shown in annex 10. Basic methods of drilling are indicated below for following as basic guide, mostly to maintain a few keydimensional specifications.

### DRILLING METHODS

1. The preferred method of drilling in consolidated compact formations is rotary or percussion with air and/or foam flush. Boreholes will be drilled 6 1/2 inches drill bits.
2. In unconsolidated loose, unstable, collapsing formations, rotary with appropriate drilling stabilizer will be used. In such a case the drilling diameters will be 6 ½ inches. If other chemical fluids or solids are used to arrest collapsing of formations, the Contractor has to use proper tube well development methods and tube well cleaning methods to ensure the tube well water is safe for drinking purposes. The Contractor will use such fluids or solids with the agreement of the Engineer Incharge.
3. Boreholes will be constructed with PVC casing, screen and sand trap. Quality of all these materials used should be in conformity with the drinking water standards.
4. 20 m of slotted screen for Shallow tube well and 20 up to 40 m for Deep Tube Well will be installed in tube wells. All cost of using proper drilling fluids and solids is inclusive of the rate per feet quoted. No additional payments will be made.

**TUBE WELL DEPTH**

Tube wells shall be drilled to such depths as to penetrate below the shallow water table aquifers and tap the first potential deeper aquifer or aquifers in confined/semi-confined conditions.

The minimum discharge for each tube wells is 0.25 gps to sustain continuous pump testing for 3 hours to ensure reliable operation of pumps fitted on them. The depth to be drilled should be, minimum twenty feet (20) feet below the main aquifer to provide proper installation of a hand pump and to provide a sand trap of 10 feet. If the discharge is less than 0.1 gallons/sec., a decision to abandon the tube well or continue to drill deeper will be at the discretion of the Contractor, validated by the Engineer incharge. Any drilling beyond 30 feet of the major strike which has supplied water greater than 0.1 gallon/ sec, Supervision Firm will not pay for that excess drilling and installation of casings etc.

**TUBE WELL DIAMETER**

1. Tube wells will be drilled with telescopic diameters.
2. The first 20 feet from the surface will have concrete grouting for sanitary protection. For this the bore hole will be reamed to minimum diameter of 6 inches and concrete grouting placed in the annular space between the casing and open tube well wall.
3. Tube well will be drilled with 6 1/2 inches bit. The reaming diameter will be based on the type of temporary casing the implementing partner will use.
4. The implementing partner must take into account the depths he has to drill and lower temporary casing to complete the drilling. This cost must be built in the quoted unit cost for drilling.
5. The client will not be responsible for any loss of temporary casing which the Contractor is unable to pull out or lost due to snapping or breaking from the completed tube wells.

**SCREEN**

1. The Contractor will use proprietary; factory-made UPVC slotted screens, the slot size and screen length depending on the aquifer materials and aquifer thickness. The Implementing partner will propose a scheme of equipment to the supervision firm who will take the responsibility of the design of the tube well. The Contractor will then assemble and place screen and casing at appropriate.
2. Slotted screens should be of ISO standard and have the following specifications: PVC Class 9/10, drinking water standards, nontoxic and in standard lengths of ten (10) feet in length, diameter of 4 inches, slot width 0.8 mm and not more than 1mm, and open area as percentage of internal surface area 9.26% per linear meter. Depending on the aquifer, the Implementing partner may choose an appropriateslot width other than 0.8 mm.

**CASING PIPE AND SAND TRAP**

1. Casing pipe should be of ISO standard and have the following specifications: U- PVC Class 10, drinking water standards, non toxic and in standard lengths of ten (10) feet in length, diameter of 4 inches wall thickness 5 mm.
2. The tube wells will be fully cased up to bottom of the tube well. The threads bothmale and female are properly cleaned with a brush and cloth before they are joined.

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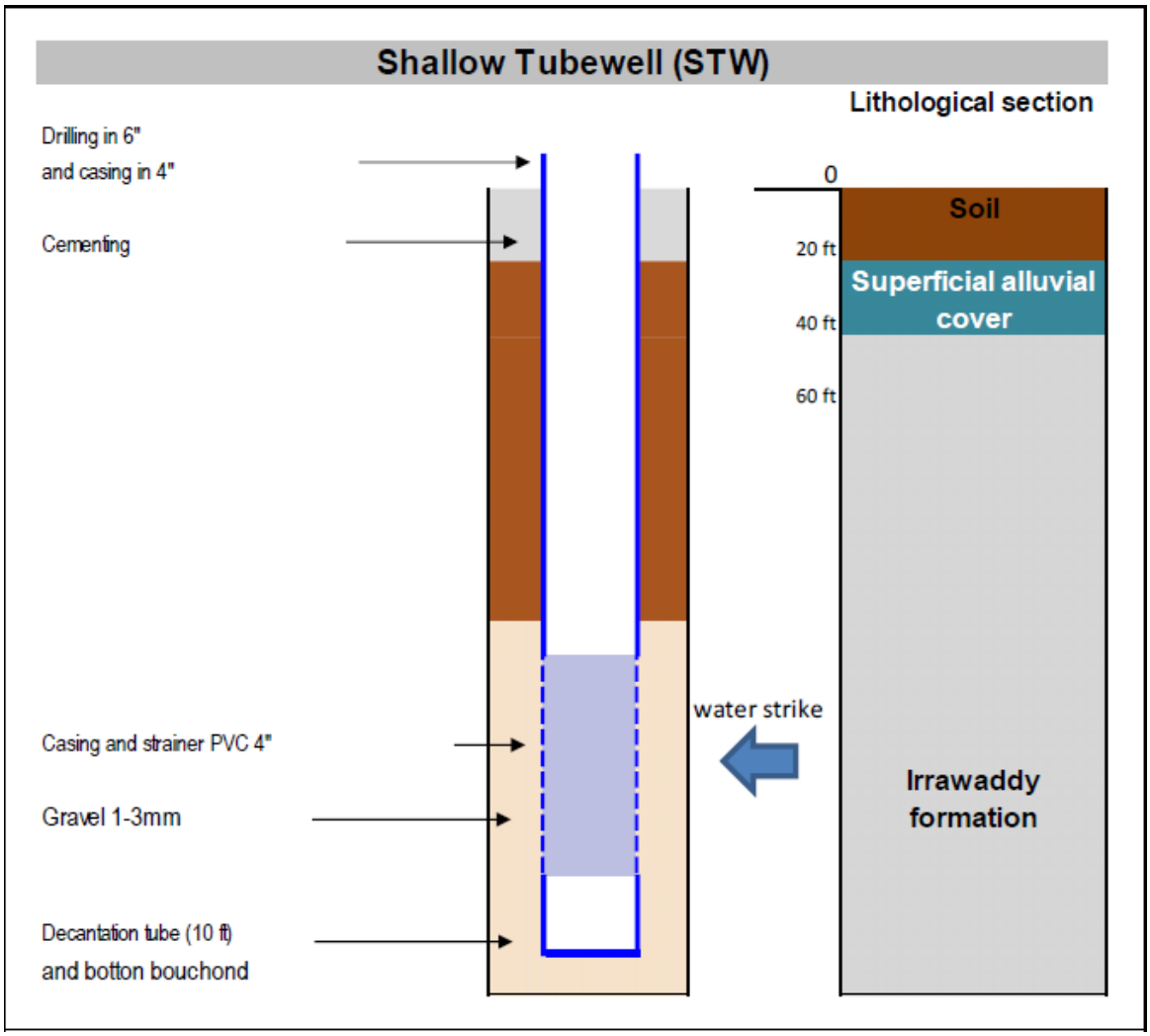
If the pipes used are with bell and socket, these are cleaned using fluids and cemented with recommended solvent cement by the manufacturers of the casing pipes and screen. Wait for recommended time for the joint set firmly before loweringit into the tube well.

3. The Contractor will take all necessary precautions during the transportation and storage of casing pipes from their warehouse to drilling site to prevent distortions, bending or deformation of the pipe that could result in eccentricity along the lengthof the pipe.
4. A maximum of 10 (10) feet length of sand trap will be part of the well design when tube wells are cased to the bottom. The sand trap will be from PVC casing pipe with specifications described above ; fitted to the end of last screen and bottom end with an end-cap. The end cap is glued with appropriate solvent cement or solutions as recommended by the UPVC manufacturer. Note that the joints sections are properly cleaned with cleaning fluids and recommended time given for the joint set firmly before lowering into the tube well.
5. Pipes and screens must be stored on a proper location and should be kept away from prolonged sunlight exposure.

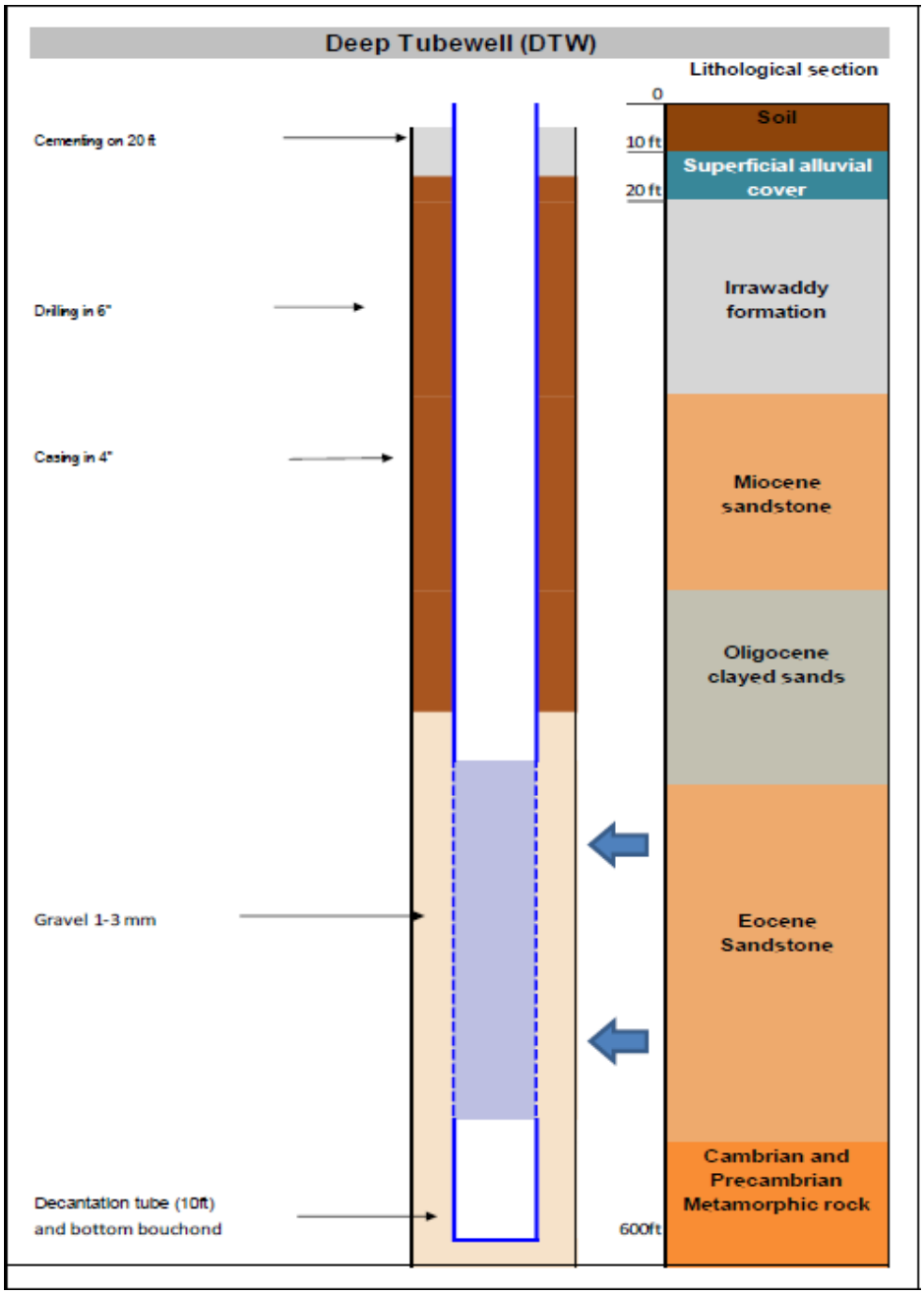
**GRAVEL PACKING AND GROUTING**

1. The annular space between the casing and tube well wall is filled with filter packing materials in the screen intervals and back filling materials. The gravel packing mixture to be used is 1-3 mm. It can be adapted to the ground condition (observing the cuttings) if necessary
2. Gravel packing is carried out as continuous feed operations done usually by two people filling uniformly along the circumference of the pipe. It is advisable to add some water with a pipe so that the gravel flows down. If the gravel gets inside the temporary casing, the casing is slowly pulled out and gentle well development is done to allow gravel to settle properly to a height of 10 feet above the top of the screen interval or the targeted water bearing formation. *The gravel will be installed using the inverse flowing: gravel is poured down during water injection from the bottom of the borehole.*
3. Backfilling and grouting is done when the Minimum acceptable yield of 0.1 gallon / second is confirmed by development. The tube well cuttings or clayey soils are back filled up to 20 feet below the ground surface.
4. The grouting is done with a concrete mix in the ratio of 1:2:3 of cement, sand and gravel respectively. The gravel size not more than 10-12 mm.

## PROFILE OF EXPECTED TUBEWELL




Note:
These 2 diagrams are indicative, and details should be followed in the narrative of the technical specification.


Deep Tubewell (DTW)
Lithological section
0
Soil
10 ft
Superficial alluvial cover
20 ft
Irrawaddy formation
Miocene sandstone
Oligocene clayed sands
Eocene Sandstone
Cambrian and Precambrian Metamorphic rock
600ft
Cementing on 20 ft
Driling in 6"
Casing in 4"
Gravel 1-3 mm
Decantation tube (10ft) and bottom bouchond

## 1.03 TUBE WELL DEVELOPMENT

On completion of drilling, the Contractor will choose a suitable and appropriate tube well development method. The tube well shall be developed for a period of one hour in order to obtain a maximum yield of water that is free of suspended matter. Developing shall be carried out by airlift pumping and surging, jetting and block surging, or other techniques the implementing partner feels is more appropriate and efficient to suit the hydro-geological and drilling conditions prevailing in that tube well.All tube wells shall be presented for testing free of any bridging or obstruction to the total depth.

## 1.04 PUMPING AND RECOVERY TEST

a. Pumping test will be for three hours for step draw down test at 0.25, 0.5 and 1 gps. Based on the estimated discharge, the Contractor will certify the tube well as either "successful" or "lost".

*b.* The minimum discharge is 0.1 gps. Pump test data should be recorded in a standard format approved by the Engineer Incharge. If the discharge is below *0.1 gps then the tube well will be regarded as "Lost".*

c. The Contractor shall have on the site a 900 V-notch weir, preceded by a tank with baffles, for the measurement of flows. Small flow (less than 0.25 liters/second) can be measured by timing the filling of a vessel of known volume. The Implementing partner shall also have on site an operating electric dip meter, calibrated in centimeters, and with visual/audible indicator of when the water level is reached.

d. Readings of flow and water level shall be taken at the intervals defined on the test pumping form. For accurate measurement, an electrical/ sonic water level indicator with graduated tape for taking water level readings. Recovery readings shall be taken for a minimum of 1 hour, during which period airlifting or pumping equipment shall not be removed from the tube well.

## 1.05 WATER QUALITY TESTING

The Contractor shall make sampling and quality analysis for arsenic and other common pollutant of water from every bore hole.

## 1.06 SAMPLING AND DRILL TIME LOGS

Representative samples of the strata intersected shall be collected every three feetor less depending on the changes of geological formation. For collection, the Contractor shall cease drilling, circulate all cuttings to the surface, resume drilling andcollect the cuttings then brought to the surface. The Contractor shall take every possible precaution to guard against sample contamination due to poor circulation, tube well erosion, or caving. Cutting samples shall be bagged, labelled with tube welldepth at time of collection, and stored in a position where they will not be contaminated by site conditions or drilling operations. The Contractor shall supply strong, transparent sample bags and labels as required. The driller in-charge will also record the drill time logs/penetration rate of each rod or at every three-meter interval.

## 1.07 CHLORINATION AFTER TUBE WELL COMPLETION

Each successful tube well must be chlorinated following completion. The Contractor will decide on the concentration of chlorine based on the volume of water in the tube well.

## 1.08 STRAIGHTNESS AND VERTICALITY TEST

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1. All tube wells shall be drilled and cased straight and vertical and all casings and screens shall be set round, plumb and true to line. Any delays encountered in running casing and screen considered to be due to poor whole alignment shall be at the Contractor's expense.

2. The Engineer Incharge may ask the Contractor to perform random tests for straightness and verticality alignment after completion of the well and before its acceptance. The Contractor shall provide the necessary 12 meter section of pipe (The plumb), not more than 15 millimeters diameter less than the inside diameter of the casing. Should the plumb fail to move freely throughout the length of the casing to the required depth or should the well vary from the vertical in excess of two-thirds of the smallest inside diameter of part of the tube well being tested per 30 meters of depth, the verticality and straightness of the well shall be corrected by the Contractor at his own expense. *Should the Contractor fail to correct such faulty straightness or verticality, the Engineer Incharge may refuse to accept the tube well and no payment for those Works and materials used.*

## 1.09 PROTECTION

During the contract period, when work is not in progress, the tube wells shall be kept capped in such a manner as to prevent the entrance of foreign materials. The Contractor shall remove any foreign matter at his own expense. On completion of each tube well, the Contractor shall supply and fit an approved permanent lock-up cap. Casing shall terminate not less than 0.5 meters above ground level and are fittedwith the approved lock-up cap.

## 1.10 TEST OF ACCEPTABILITY AND REPORTS

Subject to meeting the requirements of the maintenance period, the tube well shall be accepted for payment on presentation of the following reports at schedules shown in the table below and sample of the formats given in the annexes:

| NAME | DESCRIPTION | Time of Submission |
|---|---|---|
| 1. Pre-execution report | This report indicate all data about the work to implement (location, drawings, the rig tools to be used | At least one week before site intervention |
| 2. Certificate of Completion of drilling activities | This certificate of Completion will comprise:<br>• Strata log<br>• Pumping tests interpretation results<br>• Construction log showing casing and allinstallation for the tube well<br>- Result of the quality analysis | At least 1 weeks after drilling activitiescompletion |
| 3. Certificate of Completion of civilwork and electromechanica lactivities | This certificate of Completion will comprise:<br>• Drawings of the constructions completed<br>• All documents on the material installed | At least 2 weeks after civil work and electromechanical activities completion |

***END OF SECTION***

# GAS STOVES

## 1.01 SCOPE OF WORK:

The work will include, providing, laying, fixing and installation etc., complete in all respect; of Cooking Appliances of types and sizes as specified in the BOQ and as per approval of Engineer Incharge

All appliances shall be constructed entirely of new, unused materials and parts and shall conform to the requirements of Pakistan Standards *PS: 1560-2017; ICS NO. 97.040.20*

## 1.02 INSTALLATION:

All cooking shall be connected to the building piping by one of the following:

- Flexible pipe
- Rigid metallic pipe and fittings.
- Semirigid metallic tubing and metallic fittings. Aluminum alloy tubing shall not be used in exterior locations.

Installation shall be done by an approved representative of the vendor; in accordancewith the manufacturer's installation instructions and NFPA 54.9

## 1.03 TECHNICAL SAFETY

Installation, repair and maintenance work should be performed by an authorized service technician in accordance with local building and safety codes. Work by unqualified persons could be dangerous and may void the warranty.

Before installing the cooktop, check for externally visible damage. Do not operate a damaged appliance. A damaged gas cooktop is a hazard.

The Contractor will make sure that the appliance is properly installed and grounded by a qualified technician.

Gas Connection The gas supply (service) line must be the same size or greater than the inlet line of the appliance. This range uses a 1/2‖ (1.3 cm) ID NPT (Sch40) inlet.

The appliance must be disconnected from the gas supply piping system during any pressure testing of that system.

Manual shut-off valve: This installer-supplied valve must be installed in the gas service line before the appliance in the gas stream and in a location where it can be reached quickly in the event of an emergency. Any opening behind the range shallbe sealed.

## 1.04 CONNECTION TO UTILITIES:

The following appliance are covered by this section.

1. Tandoor, full size (Peshawari) along with 20 Rft GI Pipe and fitting brick work are included (Gas burner and internal fitting is available at site) complete in all respect with all accessories, as per BOQ and as per satisfaction of Engineer incharge.
2. 03 Burners and single burner cooking stoves, stainless steel fabrication, of approved make complete in all respect including fire stoves and accessories, as per BOQ and as per satisfaction of Engineer in charge.
3. Providing and fixing of Gas fired, Heavy Duty Cast Iron Burner, with MS pipe frame, of approved make or equivalent make complete in all respect including fire stoves and accessories, as per BOQ and as per satisfaction of Engineer Incharge.

***END OF SECTION***

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## SUB SOIL DRAINAGE PIPING

### 1.01 SCOPE OF WORK:

The work will include, providing, laying, fixing and installation etc, complete in all respect; of Sub Soil Drainage Piping around/ alongside foundation of the Main building as shown in drawing and as per the approval of Engineer Incharge.

### 1.02 PIPE MATERIAL:

Subsoil drainage pipe shall be UPVC, coiled, perforated corrugated pipes. Fittings and pipe shall be from single source of manufacture. Pipe shall be manufactured in conformity with DIN 1187.

Diameter of perforation shall be 0.1‖ to 0.15‖ and density of holes shall be 40% of total pipe surface area.

### 1.03 INSTALLATION:

Each pipe shall be examined on arrival; defective pipes shall not be used. Drain shallbe laid in straight lines and to even gradients between the levels shown, with pipes and fittings, of the type and diameter as shown on the drawings. Great care shall be exercised in setting out and determining the levels of the pipes and the Contractor shall provide suitable instruments, set up and maintain sight rails, and bench marks etc., necessary for the purpose. Cut pipe shall have smooth regular ends at right angles to length of pipe. All pipes to be cut with an approved cutter. All drains shall be kept free from earth, debris, superfluous cement and other obstructions during laying and until the completion of the Contract when they shall be handed over in a clean condition. Pipes shall be laid with the sockets leading upstream.

No pipes shall be laid on their collar or on blocks, tiles or other temporary supports.

Drainage line shall be accurately laid and shall be perfectly true to line and gradient from point to point in both vertical and horizontal planes.

Special fittings required in the installation not generally cast by manufacturers shall be got specially cast by Contractor matching with the shell thickness specified.

Branch connection shall be made with ¯WYE‖ and long ¯TEE-WYE‖ fittings. Short bends, common offsets and double hubs will not be permitted. Short ¯Tee-Wye‖ fittings are to be used in vertical piping only. All fittings shall conform to code requirements.

Sub Soil Water chamber will be constructed at locations shown in the drawings to the dimensions, sizing, levels, material as specified in the drawings and BOQ.

Pumps installed in sub soil water chambers shall follow the specifications of sump pumps (Section 8)

### 1.04 TESTING AND INSPECTION:

1. The entire drainage and vent system shall be subjected to testing after installation to ensure a leak-proof installation under operating conditions.
2. All the openings in the piping system shall be tightly closed by inserting test plugs of heavy rubber gasket that fit snugly all around the opening. The highest point will be left open to supply water and may be raised if necessary by temporary jointingto develop a minimum head of five (5) meters of water at each section of the system. Water is filled to the point of overflow and any drop in the level of water will indicate a leak that will be found by inspection. The water level will be checked for no drop for at least 15 to 30 minutes.

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3. No section will be tested at a pressure more than 6m of water. High stacks will be tested in sections, starting from the top section and then connecting top section to next lower section.

4. The drainage pipe and building sewer will also be inspected for slopes which must conform to the slopes specified. The slopes will be checked with precision angle measuring instrument like universal protector, plumb and level. Any portion found not laid according to the given slope will be rectified at the Contractor's expenses.

5. This Contractor shall furnish & pay for all devices, materials, supplies, labour and power required in connection with all tests. All tests shall be made in the presence of and to the satisfaction of the Engineer Incharge.

6. This Contractor shall also be responsible for the work of other trades that may be damaged or disturbed by the tests, or the repair or replacement of his work and he shall, without extra charge to the Employer, restore to its original condition, workof the trades so damaged and disturbed, engaging the original contractors to do the work of restoration.

7. Defects disclosed by the tests shall be repaired, or if required by the Engineer Incharge, defective work shall be replaced with new work without extra charge to the Employer. Test shall be repeated as directed, until all work is proven satisfactory.

8. This Contractor shall notify the Engineer Incharge, Employer and others having jurisdiction at least ten days in advance of making the required tests, so that arrangements may be made for their presence to witness the tests.

9. The Contractor shall submit test certificates to the Engineer Incharge & obtain his certification that the tested piping system have passed the prescribed tests.

***END OF SECTION***

# WATER PUMPS

## 1.01 SCOPE:

These specifications cover supplying, installation testing and commissioning of suction centrifugal pumps for buildings. The Contractor will submit pump curves certifying pump operation, BHP & NPSH curves to the Engineer In charge or approval, prior to the start of work.

## 1.02 SERVICE CONDITION:

Pumps shall be designed and constructed to operate satisfactorily in a typical hydronic application, and shall be the product of a manufacturer regularly engaged in the production and marketing of these pumps.

## 1.03 OPERATING CONDITIONS:

The flow rate, pump head & other required data are indicated in the equipment schedule and the pumps supplied shall conform to these requirements. The Contractor is required to ensure non-overloading selection of motor for parallelpumping operation.

NPSH required by the pump shall be stated & the NPSH as available checked by the Contractor for the specific application. The pump RPM shall be as specified in the EQUIPMENT SCHEDULE (. Pump casing shall be designed to withstand the discharge pressure specified on the Schedule Sheet plus the static head on the system, plus 50% of the total head, but not less than 125 psi (8.5 bars).

## 1.04 PUMP COMPONENTS:

Details of pump construction shall be as follows:

1. Casing shall be vertical split with centerline discharge, foot-supported and madeof cast iron. Casings shall be provided with tapped & plugged holes for priming, vent & drain.
2. Casing Connections: shall be ANSI B16.1, 125PSI (8.5 bars), ASA Standard flat face flanges.
3. Casing Wearing Rings: Easily replaceable casing wearing rings of suitable material for service shall be provided in front and rear of impeller.
4. Casing Joint Gasket: An O-ring shall be provided at the casing joint to prevent leakage.
5. Impeller: shall be the single section enclosed type of bronze. Impeller shall be statically and hydraulically balanced. Drilled holes shall be provided through the impeller hub to balance axial thrust loads and keep positive pressure on the stuffing box. Impeller shall be keyed & locked to the shaft with a hexagonal head impeller nut and shall be easily removable without the use of special tools.
6. Shaft: Pump shaft shall be high strength stainless steel sized to provide a minimum amount of deflection. Shaft shall be protected in the stuffing box area by a replaceable shaft sleeve.
7. Seal: Pumps shall be provided with gland packing seal or mechanical seal as indicated in the Equipment Schedule.

8. Bearing Frame: shall be rigid, one piece cast iron construction. Frame shall be provided with catch basin reservoir with tapped drain hole to collect and pipe away stuffing box leakage
9. Bearings: shall be ball type on both ends of the frame. Both bearings shall be locked in place and be sized to provide long life under thrust loads encountered. Both bearings shall be enclosed by replaceable box.
10. Bearing Lubrication: Ball bearings shall be grease lubricated with provisions for the addition & relief of grease.
11. Deflector: A replaceable shaft deflector of non-corrosive material shall be provided to prevent the entrance of contaminants into the pump bearings at the inboard end of the bearing frame.
12. Baseplate: shall be of heavy duty, fabricated steel or cast iron, sufficiently rigid to support the pump and the driving motor with tap hole to pipe away leakage and condensation.
13. Coupling: shall be spacer type.
14. Coupling Guard: shall be metallic and fastened to baseplate and conform to the requirements of ANSI B.15.1.
15. Rotation: Pump shall have clockwise rotation viewed from its driven end.
16. Motor: Motor shall conform to specifications given. It shall be selected in accordance with the pumps non-overloading performance characteristics. Motors shall be mounted with pump on baseplate in manufacturer's plant and shipped as one unit.
17. Foundation: Foundation for the pump shall be 4000 psi concrete, sized to provide an inertia block having a mass equal to 3 times the weight of the pump and motor. The foundation shall be isolated from the structure and plant room floor by using 40mm thick high density cork. Edges of the foundation shall be provided with 25_25_3mm angle iron frame work and painted with two coats of oil paint. When shown on drawings, or with pumps mounted on upper floors, the pump's concrete foundation shall be supported on four suitably sized spring isolators.

## 1.05 INSTALLATION:

During installation, the pump shall be properly leveled, grouted in and realigned before operation in accordance with the manufacturer's recommendations. Suction & discharge connections shall be installed through flexible connectors, and electrical wiring shall be done. Drain lines from pump base plate at drip pocket shall be installed equal to the size of the opening.

## 1.06 COMMISSIONING AND TESTING:

The pump shall be commissioned and tested by the Contractor, in accordance with the manufacturer‘s recommendations. The pump operational curve shall be identified by taking no-flow reading and shall be charted on the pump curve. Operational point at full flow shall be identified and submitted to the Engineer Incharge. Tests shall be conducted and test reports submitted to the Engineer Incharge and approval obtained.

## 1.07 PUMP SCHEDULE:

| Location | | Pump Type | Location | Quantity | HP | Single Phase | Three Phase | Pump Type | Location | Quantity | HP | Single Phase | Three Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAIN BUILDING | BASEMENT 2 | Pressured Water Supply | AHU-11 | 1 | 0.5 | ✓ | --- | Suction Pump | Near Ramp | 1 | 1 | ✓ | --- |
| | | Pressured Water Supply | AHU-12 | 1 | 0.5 | ✓ | | | | | | | |
| | BASEMENT 1 | Centrifugal Pump | Near Engg Room | 1 | 5 | --- | ✓ | Suction Pump | External | 2 | 1 | --- | ✓ |
| | | | | 1 | 5 | | ✓ | | | 1 | 1 | | ✓ |
| | GROUND FLOOR | Submersible Pump | Near Wide Passage | 1 | 20 | --- | ✓ | Sludge Pump | Near Wide Driveway | 1 | 2 | --- | ✓ |
| | | Pressured Water Supply | AHU-1 | 1 | 0.5 | ✓ | --- | | | | | | |
| | | Pressured Water Supply | AHU-2 | 1 | 0.5 | ✓ | | Suction Pump | Near Wide Driveway | 1 | 2 | | ✓ |
| | | Suction Pump | Near Ramp | 1 | 2 | | ✓ | | | | | | |
| | | | | 1 | 2 | | ✓ | | | | | | |
| | | Submersible Pump | Near Septic Tank | 1 | 0.5 | ✓ | --- | | | | | | |
| | MEZZANINE FLOOR | Pressured Water Supply | AHU-3 | 1 | 0.5 | ✓ | --- | | | | | | |
| | | Pressured Water Supply | AHU-4 | 1 | 0.5 | ✓ | | | | | | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Pressured Water Supply | AHU-5 | 1 | 0.5 | ✓ | |
| | | Pressured Water Supply | AHU-6 | 1 | 0.5 | ✓ | |
| | FIRST FLOOR | Pressured Water Supply | AHU-7 | 1 | 0.5 | ✓ | --- |
| | | Pressured Water Supply | AHU-8 | 1 | 0.5 | ✓ | |
| | SECOND FLOOR | Pressured Water Supply | AHU-9 | 1 | 0.5 | ✓ | --- |
| | | Pressured Water Supply | AHU-10 | 1 | 0.5 | ✓ | |
| | ROOF | Pressured Water Supply | FA-AHU-1 | 1 | 0.5 | ✓ | --- |
| | | Pressured Water Supply | FA-AHU-2 | 1 | 0.5 | ✓ | |
| **FLATS** | GROUND FLOOR | Centrifugal Pump | Near Stairs | 1 | 1 | ✓ | --- |
| | | | | 1 | 1 | ✓ | |
| **BUNGALOW** | GROUND FLOOR | Centrifugal Pump | Near Stairs | 1 | 1 | ✓ | --- |

***END OF SECTION***

# ELECTRICAL WORKS

# GENERAL SPECIFICATIONS

# GENERAL SPECIFICATIONS

## FOREWORD

This document is to describe the minimum requirements for the equipment and installations and to ensure that the Contractor is fully aware of his duties to perform the required works, in accordance with the terms of the Contract.

## 1. SCOPE OF WORK

The works related to the electrical system which are included in the scope of this Contract are shown on the Drawings, stated in the Particular Specifications, Bill of Quantities and explained in these specifications. The works shall broadly include but not limited to the following:

| | |
|---|---|
| 1 | Medium Voltage Dry Type Distribution Transformer |
| 2 | Medium Voltage Switchgear |
| 3 | Medium Voltage Cables |
| 4 | Low Voltage Switch Boards / Distribution Boards |
| 5 | Low Voltage Cable and Wires |
| 6 | Uninterrupted Power Supply (UPS) |
| 7 | Conduits and Pipes |
| 8 | Busway System |
| 9 | Wiring Accessories |
| 10 | Interior Lighting |
| 11 | Emergency Lighting |
| 12 | Exterior Lighting |
| 11 | Lighting Poles and Accessories |
| 12 | Earthing System |
| 13 | Cable Tray, Ladder and Trunking |
| 14. | Lightning Protection System |
| 15 | Structured Cabling System |
| 16 | Fire Alarm System |
| 17 | Public Address System (IP Based) |
| 18 | Access Control System |
| 19 | CCTV System (IP Based) |
| 20 | CATV System |
| 21 | Standby Diesel Generator System |

All material and equipment supplied by the Contractor shall be new and in all respects conform to the high standards of Engineering design, workmanship, performance and function as here in specified and fully meet the quality level and rugged requirements of the specifications.

The Contractor shall also be responsible to supply any other equipment not specifically mentioned in these documents but which is necessary for proper operation of the works / system, shall be considered to have been so specified and accordingly shall be provided by the Contractor as part of the Contract.

The Contractor shall be solely responsible for ensuring proper functional requirements of various equipment and shall also be responsible for furnishing any additional piece of equipment and for making modification in the equipment as desired and / or approved by the Owner or his representative, to achieve proper coordination with various equipment offered in the bid and also those installed by others.

Approval of the Contractor's supplied equipment / installation works shall not relieve the Contractor of any of his obligations or liabilities under the Contract, except insofar as provided under the conditions of the Contract.

## 2. RULES AND REGULATIONS

The entire electrical installation / work shall be carried out by licensed contractor, authorized to undertake such work under the provisions of Electricity Act 1910 and The Electricity Rules 1937 as adopted and modified up to date by the Government of Pakistan.

All works shall be carried out in accordance with the latest edition of the Regulations of the Electrical Equipment of Buildings issued by the Institute of Electrical Engineers - London, the Contract documents, the Electricity Rules 1937 and bye-laws that are in force from time to time. Any discrepancy between these specifications and any other rules and regulations shall be brought to the notice of Owner or his representative, and his decision shall be final and conclusive.

The Contractor shall be responsible for completing all formalities and submitting the test certificates as per prevailing rules and regulations and shall have the installation passed by the Government Electric Inspector of that region. All requirements of the Electric Inspector and the Electric Company shall be complied with.

## 3. STANDARDS

All works, equipment and materials shall conform to:

On the one hand:

The specification recommended practices, official standards and codes the non - restrictive List of which is given below.

International Electro-technical Commission (IEC)

British Standards (BS)

National Electric Code (NEC)

National Standards

In the event of conflict between standards, the most stringent shall prevail.

Whenever the electrical equipment to be installed, does not hold national standards, the Contractor shall take into account the specific standards chosen by the Owner and make sure that the equipment he has to install, meets these standards.

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In addition, even if no mention is stipulated in this specification, it is implied that the equipment be tropicalized, if required, by the conditions of the site of installation.

In any case, the standards and codes to be taken into consideration are those in force at the date of delivery.

## 4. INSTALLATION AND SERVICE CONDITIONS

### 4.1 Site Conditions

All material and equipment supplied and installed shall be designed, manufactured and tested to meet the following ambient conditions unless specifically stated otherwise for any material / equipment:

| | | | |
|---|---|---|---|
| a) | Maximum outdoor ambient temperature | : | 45 degree C |
| b) | Minimum Indoor ambient temperature | : | 0 degree C |
| c) | Maximum relative humidity | : | 75 % |
| d) | Minimum relative humidity | : | 25 % |

### 4.2 Service Conditions

Equipment shall be designed and built for continuous service with a minimum of supervision and maintenance.

## 5. MAIN ELECTRICAL CHARACTERISTICS

### 5.1 Power Supply System

Unless otherwise specified elsewhere, all equipment and material shall be designed to operate and function satisfactorily with the following minimum requirements without any de-rating:

- - Voltage 400 ± 10%
- - Phase 3, 4 wire system
- - Frequency 50 Hz. ±2 Hz.

### 5.2 Degree of Protection of Enclosures

For indoors, IP23 minimum degree of ingress protection of the enclosures against contact with line or moving parts and against ingress of solid foreign bodies or liquids, shall be selected, in accordance with IEC 60529.

## 6. GUARANTEE

The Contractor shall furnish written grantee which should clearly state that the works he will carry out as well as the materials he will supply, meet with this specification and that compliance thereto

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constitutes an official clause, added by implication to the general conditions of his offer when signing the Contract.

Guarantee shall also be for replacement and repair of part or whole of the equipment which may be found defective in material or workmanship. The grantee shall cover the duration of Maintenance Period as defined in the conditions of the Contract. This guarantee shall not relieve the Contractor of his obligations and he will fully be responsible for the repair or replacement of any defective material in time, so as not to cause any undue delay in carrying out the repairs and/ or replacements.

The Contractor shall acquaint himself fully with the existing conditions and limitations at site and all works necessary to complete the project under the Contract, to be carried out by the Contractor.

## 7. EXCEPTIONS TO SPECIFICATION

Any exception or deviation from this specification or the codes and standards shall be listed separately in the Contractor's "List of Deviations". Any exception, which shall not be listed, shall not be considered later.

## 8. AVAILABILITY OF SPECIFICATIONS, DRAWINGS AT SITE

The Contractor shall assume at his own cost the permanent availability of this specification and drawings on site where applicable.

## 9. DISCREPANCIES IN TENDER DOCUMENTS AND DRAWINGS

The Contractor shall carefully examine the documents and drawings and if he finds any discrepancies or omissions from the specifications, bill of quantities or drawings, or is in doubt as to the meaning, he shall at once notify the Owner or his representative for receiving his instructions before proceeding with the works. If such defective or modified work is carried out by the Contractor on his own, he shall rectify the same at his own cost.

## 10. MEASUREMENT OF WORKS

The quantities set out in the bill of quantities are the estimated quantities and they shall not be taken as actual and correct quantities of work to be executed by the Contractor. The Contractor shall carry out actual measurement of works at the site.

## 11. INSTALLATIONS DETAILS

The locations, routings, installation heights, detail etc. for electrical equipment are indicated on the drawings. If any information is not stated on the drawings or wherever modifications are required the Contractor shall obtain prior instructions from the Owner or his representative.

## 12. DRAWINGS AND DATA

The Contractor shall provide dimensional outline drawings, arrangement drawings and technical data for the equipment offered, for the approval of Owner or his representative.

## 13. PRIOR APPROVAL OF SHOP DRAWINGS, MATERIALS AND EQUIPMENT

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The Contractor shall provide shop drawings for the electrical installations showing the exact routes of all underground cables and ducts, the exact run of all conduits and trunking, draw-in and junction boxes, the number and size of wires in each conduit, the final connection arrangements at distribution boards and the details of ducts for the approval of consultant / Owner's representative before commencing any portion of the works. All such working drawings shall be submitted in suitable number of copies as indicated in the particular conditions and within the periods stipulated below:

a. Cable entry ducts into buildings.

b. Working drawings shall be submitted within two weeks of handing over the site. All other working drawings shall be submitted to the Engineer against signed receipt and dated within two months of signing the Contract. Should however the Contractor be obliged to install electrical conduits prior to this period then he shall submit the relevant working drawings at least two weeks prior to the proposed date of commencement of the work. The Contractor shall submit the program indicating the dates on which coordination in different sections will take place, together with the submission of the working drawings. The Engineer shall arrange to return to the Contractor at least one week prior to the commencement of concreting of the section, his comments or approval of the working drawings.

The Contractor shall supply detailed specifications, dimensional drawings, etc., of equipment that he proposes to supply and install.

Where this Contract requires the approval of Engineer to material and goods, the Contractor must seek to obtain this approval within eight weeks after signing of the Contract. No extension of time will be granted for non-availability of material or goods if this clause is not complied with. Approval of the Engineer does not relieve the Contractor of placing his orders in due time for the materials he needs to complete the Contract on time. The approved samples shall be retained on site for comparison with commodities used in works and removed when no longer required.

## 14. MATERIAL ORIGIN AND QUALITY

The material and equipment shall be purchased from Consultant / Owner's agreed suppliers.

The consultant / owner shall retain the right to at any time demand the indication of origin of the materials, and to eventually refuse products, the origin of manufacturing of which have not been previously agreed to without consideration of quality.

On specific agreement of the Owner, the materials may be delivered progressively to the field, but in such a manner as to allow sufficient time for their reception.

When choice of manufacturer is allowed for any particular commodity the Contractor shall obtain the whole quality required to complete the work from one manufacturer or obtain approval of any change in source of supply. He shall produce written evidence of sources of supply when requested to do so by the Engineer.

## 15. IDENTIFICATION OF EQUIPMENT

For each piece of equipment, identification label shall be fitted in front of the casing. The label shall have block letter 7mm high, black on white back ground of trifoliate and fixed with screws.

## 16. MARKINGS

The contractor shall provide ―Danger Boards‖ and‖ Shock Charts‖ wherever required to comply with the requirements of local Electricity Rules and according to normal practice.

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## 17. FACTORY TESTS

All equipment supplied by and installed as part of the Contract such as distribution boards and like shall be fully tested at the manufacturer's works to the requirements of appropriate standards called for later in the particular specification.

The Contractor shall inform the Engineer in writing about the date and time of test of each equipment at least two weeks in advance. The witnessing of test by the Owner or his representative shall not absolve the Contractor from his responsibility for the proper functioning of the equipment and for furnishing the guarantees referred to in Clause 6.0. All test results in the form of certificate of test / test record certificates, signed by all the witnesses, for each item in the scope of Contractor's supply shall be supplied to the Engineer within seven days of the test date, and in any event before delivery to the site.

All expenses for carrying out the tests and witness by the Owner or his representative shall be borne by the Contractor and deemed to have been included in the tender bid.

## 18. STORAGE

The Contractor shall store the equipment in such conditions that it cannot be damaged, i.e., in a dry warehouse. As particular concerns; fragile components, these shall be stored on shelves in their original packing, fitted with identification labels so as to avoid unnecessary manipulation or handling.

The Contractor shall handle, store and fix each commodity in accordance with the manufacturer's recommendations. He shall inform the Engineer if these conflicts with any other specified requirement and submit copies of manufacturer's recommendations to the Engineer when requested to do so.

## 19. LABOR AND STAFF OF CONTRACTOR

The Contractor shall provide / furnish and arrange for:

- Skilled and unskilled labor required for performing the works in accordance with the technical specifications and drawings within the agreed time schedule.
- Supervisory technical staff with appropriate experience and requisite expertise to ensure quality of work performed.
- Supervisory administration and clerical staff to ensure smooth functioning of the activities at site.
- Construction equipment, megger testers, tools, etc.

The Contractor shall supply all labor, materials and equipment necessary for the installation of low voltage distribution boards, cables, lighting and power equipment, together with all other apparatus shown on the drawings and as detailed in the Particular specification.

## 20. SMALL INSTALLATION MATERIAL

The Contractor shall supply all small installation and consumable materials such as nuts, bolts, washers, shims, angles, leveling materials, insulation tape, solder, PVC strap-on or heat shrinkable type cable tags, cable ties, bushes, sealing compound, Avometer, electrical testing and measuring instruments, etc., and all such other material not listed in BOQ, required for complete installation as intended by the specification and scope of works.

## 21. INSTALLATION INSTRUCTIONS - GENERAL

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The Contractor shall set out the works himself as per specifications and drawings and shall properly position the equipment on specified foundation / location. In general, the manufacturer's instructions for installation shall be followed. Any defect or faulty operation of equipment due to Contractor not following the manufacturer's instructions shall be corrected and repaired by the Contractor at his own cost.

## 22. ASSOCIATED CIVIL WORKS

The expression `Associated Civil Works' shall mean civil work to be carried out by the Contractor under the direction of the Engineer in connection with the Electrical Service.

The Contractor shall prepare accurate drawings giving details of all holes, fixings, bases and other civil work requirements and shall be responsible for their accuracy. The cost of preparing shop drawings shall be considered to have been so specified in the tender price.

The following is a summary of the work to be carried out by the Contractor:

a. The cutting and forming of holes for conduits or pipes, or conduit or pipe fixings through walls, floors, ceilings, partitions, roofs, etc., and making good after the work is sufficiently advanced.

b. The building of concrete and / or brick ducts in floors, walls, etc.

c. The formation of concrete bases, etc., for equipment

d. Excavation forming for underground services of ducts and courses and then covers it.

e. The cutting or forming of chases, recesses, etc., in floors, walls, etc., for conduits and fittings in and making good.

f. Excavation and laying of cable carrying pipes.

g. The building in of brackets and supporting bars or other form of conduit or pipe suspensions.

h. The painting of all pipes, tube and conduits etc. after fixing unless specified to the contrary.

i. The providing and building in of sleeves through slabs and walls.

In general all required holes through walls, floors and beams for pipes and ducts will be left out by the Contractor during the process of building.

Where conduits, pipes or fittings are fixed to concrete or woodwork by means of saddles or clips, the Contractor shall himself execute the work necessary and the cost of such work shall be considered to have been so specified in the price.

Cutting, fitting, repairing, patching or plastering and finishing of carpentry work shall be done by craftsmen skilled in their respective trades, when cutting is required it shall be done in such a manner as not to weaken structure, partitions or floors. The holes required to be cut must be directed without breaking out around the holes. Where patching is necessary in finished areas of building, the Engineer shall determine the extent of such patching or refinishing.

## 23. TESTING - GENERAL

Upon completion of installation, at least seven days notice is to be given of intention to perform any test. The Contractor shall perform all static, semi-dynamic (by simulation), and dynamic field testing on all the equipment and systems.

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All tests shall be conducted in the presence of the Engineer for the purpose of demonstrating equipment or system compliance with specifications. The Contractor shall submit for Engineer's approval complete details of tests to be performed describing the test procedure, test observations and expected results.

The Contractor shall furnish all tools, instruments, test equipment, materials, etc., and all qualified personnel required for the testing, setting and adjustment of all electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the Contractor shall be responsible for adequate protection of all personnel and equipment during such tests. The cost of any damages or rectification work due to any accident during the tests shall be the sole responsibility of Contractor.

The Contractor shall record all test values of the tests made by him on all equipment. Four copies of all test data and results certified by the Engineer shall be given to the Engineer for record purposes. These shall also include details of testing method, testing equipment, diagrams, etc.

The witnessing of any tests by the Engineer does not relieve the Contractor of his guarantees for materials, equipment and workmanship, or as any obligations of Contract.

In addition to installation testing, the Contractor is to carry out operation testing of all sections and is to clean, set, calibrate and fully commission, demonstrate and hand over to the Owner the entire Contract works in a thoroughly complete and operational state to the satisfaction of the Engineer.

The acceptance - provisional or final- shall be made by the Owner. This reserves him the right to be represented or assisted by a representative or an organization ( whether official or not) of his choice, which may decide on his behalf any repairs deemed necessary resulting from lack of observations of this specification, or of the rules and standards. In addition, he may judge the quality of the works and the materials supplied.

This remains in force in case of sub-contracting.

The Contractor shall formally engage his direct responsibilities to the Owner or his representative, and likewise, shall assume all responsibility for work performed by sub-contractors and materials he has supplied and installed.

## 23.1 Insulation Resistance Test

Insulation resistance test shall be made on electrical equipment by using a megger of 1000 volts for circuits between 250 and 500 volts. The insulation resistance of distribution boards, cables, etc., shall be as per IEC, IEEE, BSS and Pakistan Electricity Rules.

The distribution boards shall be given an insulation resistance measurement test after installation, but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters, if equipment is found to contain moisture. Where corrective measures are carried out, the insulation resistance readings shall be taken after the correction has been made and repeated twice at 12 hours interval. The maximum range for each reading in the three successive tests shall not exceed 20% of the average value. After all tests have been made, the equipment shall be reconnected as required.

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### 23.2 Earth Resistance Test

Earth resistance tests shall be made by contractor on the earthing system, separating and reconnecting each earth connection as may be required by the Engineer. If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The electrical resistance of the E.C.C. together with the resistance of the earthing lead measured from the connection with earth electrode to any other position in the completed installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earthing sets are installed, the earth resistance test between two sets shall be measured by means of Resistance Bridge Instrument. The earth resistance between two sets shall not exceed one ohm.

### 23.3 Switchgear

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams given by the manufacturer.

The Contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses, disconnect switches, number of interlocks, indicating lights and alarms shall be in accordance with approved manufacturer drawings. Nameplates shall be checked for proper designation of equipment served. Protective relays shall be tested and set at site prior to commissioning of the equipment.

### 23.4 Special Systems Tests

The special systems such as telephone, intercom, etc., shall be tested according to the procedures laid down in the respective sections of the technical specifications. However, any specific tests recommended by the manufacturer shall also be carried out as approved by the Engineer.

### 23.5 Complete Tests

After any equipment has been tested, checked for operation, etc., and is accepted by the Engineer, the Contractor shall be responsible for the proper protection of that equipment so that subsequent testing of other equipment do not cause any damage to the already tested equipment.

## 24. ELECTRICAL CONNECTION

Electrical connection for each building shall be supplied by other but necessary arrangement coordination to be done by this Contractor.

## 25. AS BUILT DRAWINGS AND SERVICE MANUALS

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A record shall be kept as the work proceeds of any work not in accordance with the working drawings, and upon completion of the work, the Contractor shall prepare the following drawings and forward them to the Engineer for approval:

a. Duplicate prints of as built single line diagram of the main and sub main distribution network, indicating all cables, their size and type, and the rating of all protection devices such as circuit breakers, fuses, etc.

b. Duplicate prints of as built drawings of Lighting, Power, Telephone, Data, Fire Alarm, Nurse Call, Public Address, CCTV, Access Control, Queue Management systems, as applicable.

c. Duplicate prints of as fixed control and wiring diagrams for the equipment installed as part of the Electrical Contractor works.

After these drawings have been approved, the Contractor shall supply two prints on paper of each and insert these in the operating and maintenance manual specified below.

The Contractor shall submit to Engineer for approval a sample of manufacturer instructions for installation, testing, commissioning, operation and maintenance manuals including manuals of spare parts and tools of the equipment. Upon acceptance, the Contractor shall supply three copies to the Engineer for forwarding to the Owner. These manuals should be in properly bound form. At least two copies of the documents shall be submitted in original. The installation instruction shall be submitted two weeks prior to commencement of installation of each equipment, and operation and maintenance instruction at the time of commissioning. If the Contractor fails to provide the documents, the Engineer shall withhold issuance of requisite certificates and deduct suitable amount from the payments to the Contractor.

## 26. WORK COMPLETION

The Contractor shall further make good, repair, replace all defective works and clear away on completion and leave all installations in perfect working order and to the satisfaction of the Owner or his representative.

## 27. PAYMENT

No separate payment shall be made for work involved within the scope of this section unless specifically stated in the Bill of Quantities or herein.

# DRY TYPE POWER TRANSFORMER

# DRY TYPE POWER TRANSFORMERS

## 1. GENERAL

### 1.01 DESCRIPTION

A. Work Included:

1. The scope of work under this section includes the following for Dry - type distribution transformers with medium-voltage primaries as specified here in.
2. The contractor shall supply, install, commission & test dry cast resin transformer complete with connections, terminations and accessories. The cast resin transformer shall be designed and manufactured for continuous indoor operation in a tropical climate on a 3 phase distribution system with solidly earthed neutral. It shall be of a short circuit, impulse and moisture-proof design. The case resin transformer shall be designed, manufactured and tested according to the latest edition of International Electro technical Commission (IEC) Standard 60076-11. It shall be compact and suitable for easy installation on site.
3. The transformer shall be designed to operate in an enclosure of the protection class IP23 without de-rating.
4. The electrical connections to other equipment shall be properly coordinated to form a complete system (s) complying with this specification.
5. Workshop drawings shall be provided for each transformer. These drawings shall include fully dimensioned external and internal general arrangements showing all principle dimensions, weights, foundation/cable/bus bar entry details and the positions of all functional devices, schematic drawings showing all windings, method of connection, terminal markings, and IP rating.
6. Transformers in the context of this specification shall comprise assemblies of a magnetic core, primary and secondary windings, supporting framework and enclosure.
7. Unless otherwise specified all terse used shall comply with IEC 60076-11 and DIN/VDE standards
8. The design, manufacture, selection, installation, testing, commissioning and subsequent maintenance of all equipment and materials described in this specification shall comply with the requirements of, the electricity at work regulations and the IEE wiring regulations.
9. Where more onerous requirements are specified herein, the conditions of this specification shall take precedence.

### 1.02 PROJECT CONDITIONS

A. GENERAL

The transformers shall comply with the requirements of IEC 60076 - 11 in respect of partial discharge, impulse withstand short circuit strength.

B. SERVICE CONDITIONS: IEEE C37.121, usual service conditions

C. RATED VOLTAGE

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Unless otherwise specified the rated voltage class of the primary windings shall be 11kV and secondary windings 0.415 kV, at a frequency of 50Hz. The windings shall be connected for vector group DYn11.

D. THERMAL RATING

Transformers shall be designed and manufactured to operate continuously at the nameplate rating, in an ambient temperature not exceeding 50 deg C and RH not exceeding 100%, unless otherwise specified.

The manufacturer shall confirm any de-rating necessary, should the transformers be required to operate in conditions exceeding those specified.

Transformers which are mechanically cooled shall have increased thermal range not less than 40% of the name plate rating.

E. LOSSES

Losses at no-load and loaded conditions shall be the lowest achievable for the transformer type specified. These losses shall be stated in the schedule(s) which accompany this Specification.

F. NOISE LEVELS

The manufacturer shall confirm the guaranteed noise levels, Measurement of sound levels shall comply with IEC 60076-10. The transformer shall be provided with noise reduction support blocks in order to reduce noise level.

G. ELECTROMAGNETIC COMPATIBILITY

Radiation of electromagnetic signals shall not exceed the limits of BS 800 and BS 6667.

Where transformers may be vulnerable to voltage transients, they shall be protected by surge suppressor, which will reduce transients below the levels of the type tests.

## 1.03 QUALITY ASSURANCE

Electrical components, Devices and Accessories; Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

## 1.04 SUBMITTALS

1. Only type-tested transformer will be considered.
2. Upon the request of the Engineer, the Contractor shall submit type test certificate issued by a National or International Testing Authority such as ASTA or KEMA on type tests which have been successfully performed on the transformer tendered.
3. The type test certificate shall show evidence of the following test:
    1. Impulse voltage withstanding tests made in accordance with IEC 76 and IEC 60.
    2. Temperature rise tested in accordance with IEC 76.

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3. Short-circuit tested in accordance with IEC 76. Oscilloscopic records shall also be submitted.
4. Measurement of zero-sequence impedance.
5. Measurement of acoustic sound level.
6. Measurement of the harmonics on the no-loads current.

4. Should modifications be made to the manufacturer detail on the transformer, which may affect any, or all of the performance obtained from type tests already completed, the relevant type tests shall be repeated at the expense of the Contractor
5. At the appropriate stages of the Contract, the following shall be submitted for approval:
   1. Detailed schedule of equipment and components and manufacturer's data.
   2. Electrical control wiring diagrams.
   3. Manufacturer's recommendations on all adjustable tripping devices.
   4. Equipment weight.
   5. Builders work requirements.
   6. Heat dissipation from the transformer.
   7. Testing and commissioning procedures.
   8. Site test report.
   9. As built drawings.
   10. Operation and maintenance procedures.

## 2. PRODUCTS

### 2.01 MANUFACTURERS

Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the list of manufacturers given.

### 2.02 DESIGN REQUIREMENTS:

A. CORE CONSTRUCTION

The transformer core shall be built of lamination, comprising grain orientated silicon sheet steel which is insulated on both sides. To protect the core against corrosion and improve noise levels the core assembly shall be coated after assembly with resin based paint.

The lamination shall be clamped at top and bottom by steel channels, which are interconnected by vertical steel bolts. The bottom steel channels shall be used to support the transformer and the top steel channel shall incorporate lifting lugs.

The bottom core clamping channels shall be bolted to supporting steel cross-channels placed at 90o to the transformer length, such that the whole unit is stable and able to support the whole weight of the transformer with a safety factor of two. Wheels shall be fitted to the cross-channels which shall be bi-directional or steerable

The supporting cross-channels shall be insulated from the core- clamping channels by anti-vibration pads.

The core-clamping and supporting steel work after all forming, drilling and shaping operations shall be thoroughly digressed and rinsed prior to application of a zinc phosphate primer, rinsed again and finally coated with an oven baked epoxy paint.

B. COIL CONSTRUCTION

Each transformer shall be a double wound type with both the H.V. and L.V. windings individually encapsulated in rigid steel mould. The coils shall be impregnated with quartz filled epoxy resin and cast under vacuum, to produce a smooth finish without voids and undulations.

The size and spacing of the conductors used in the windings shall be such that the coils are self-supporting prior to impregnation and where applicable, shall allow the epoxy resin to fill all of the space in and between adjacent layers and turns.

The coefficients of expansion of the windings and epoxy resin shall not differ by more than 15%.

The windings shall be made of copper, utilizing round or rectangular sections, or foil, as detailed in the attached schedule(s)

C. MECHANICAL FORCED VENTILATION (AF)

Where specified mechanical forced ventilation shall be employed to further cool the transformer windings and thus increase the performance rating during short highly loaded periods.

The cooling system shall be automatically controlled by sensing the low voltage top winding temperature.

The system shall comprise a number of single-inlet, single-width centrifugal fans, each connected to a discharge duct situated directly below the transformer coils, or axial fans, situated to direct the air flow through the coils.

Duct work shall be of sheet metal construction to DW/142 low pressure classification, or of greater thickness to suit manufacturing procedures, or incorporated as part of the base frame construction if required.

Ducts shall have discharge outlets, protected with metal mesh screens to exclude debris, to correspond with core positions on each side. Ends shall be capped.

Fans shall have spigot inlets, with 6 mm protective wire guard, and flanges outlets to connect to mating flanges on the air ducts, and joint to incorporate a flexible gasket.

Fans shall be direct driven by an internally fitted external rotor type motor with extended lubricators.

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Each motor shall be supplied from a starter, complying with DIN/VDE standards and shall be housed in a purpose-mad cabinet also accommodating automatic control elements and status indication lamps.

The duty of each fan shall be identical and selected so that the total quantity of air delivered is sufficient to maintain the transformer temperature within the specified limits.

Fans shall be type tested to DIN/VDE Standards Impeller shall be mild steel to DIN/VDE standards and of welded construction, shaft height machined steel, bearings roller type or sealed for life. Fan scrolls shall be of welded construction.

For shaft powers below 1kW stamped formed strip impellers may be used provided required efficiency and balance grade can be achieved.

Where fan static pressure is less than 1kpa lock-formed joints and spot welds may be used.

Fans and ductwork shall have a fully protective paint system to the same standard as the core construction.

D. INTERTURN INSULATION

High and low voltages coils shall be provided with very high integrity inter turn insulation to Class F, to withstand the thermal and mechanical stresses under the specified operating conditions.

E. MOUNTING OF COILS

Coils shall be sandwiches between the core clamping channels but separated from them by insulated support blocks. These blocks shall be radially located top and firmly fixed to withstand vibration and absorb coil expansions and contractions.

F. INSULATION CLASS

The HV and L.V windings shall be of insulation class F in respect of mechanical and electrical strength (Partial Discharge Test). The maximum continuous operation temperature shall be within the limit of the maximum system temperature according to IEC 60076-11 i.e. 155oC.The maximum temperature rise shall be limited to 90K at 50oC ambient. The transformer shall operate at higher ambient temperature with reduced load without getting damaged.

G. DEGREE OF PROTECTION

When specified, a transformer enclosure shall be designed to suit the location and anticipated environmental conditions. This shall provide a degree of protection not less than IP23 in compliance with IEC 60529, and shall comply with their Electricity at work Regulations.

H. TYPE OF RESIN, FILLER ETC

The particular manufacturer's insulation system shall dictate the type of resin and filler but the following guidelines shall be complied with.

The resin shall ensure a minimum power frequency breakdown stress 10kV/mm when tested to IEC 60243.

The completed cast resin coil shall be self extinguishing in the event of fire. The testing method shall comply with IEC, DIN/VDE standards. Type test certificates are required to confirm the above.

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## 2.03 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: Cast Resin and with insulation system rated at 220 deg C with and 80 deg C average winding temperature rises above a maximum ambient temperature of 45 deg C.

B. Primary Connection: Air Terminal compartment with removable cover and predrilled copper bus bars.

C. Secondary Connection: Air terminal compartment with removable cover and predrilled copper bus bars.

D. Secondary Connection: Transition terminal compartment with connection pattern to match switchgear.

E. Insulation: Rated at 220 deg C with temperature rise of 115 deg C, maximum rise above 45 deg C.

F. Basic Impulse Level: 95 kV

G. Full-Capacity Voltage Taps: Four, 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable de-energized, tap changer; position indicator and padlock hasp.

H. Cooling System: Force cooled.

I. Sound level may not exceed sound levels listed in BS, without fans operating.

J. Impedance: 6.0 percent.

K. High Temperature Alarm: Local, audible and visual alarm and contacts for remote alarm.

# 3. EXECUTION

## 3.01 INSTALLATION

A. Install and anchor transformers on concrete bases according to manufacturer‘s written instructions and according to seismic codes applicable to project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
2. Use 3000-psi (20.7 – Mpa), 28 day compressive strength concrete and reinforcement as specified in Division 03 Section ¯Cast in Place Concrete‖.
3. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm) centers around full perimeter of base.
4. Anchor equipment with epoxy embedded anchor bolts that extend through concrete base and anchor into structural concrete floor.

B. Maintain Minimum clearness according to manufacturer‘s written instructions and NFPA 70.

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## 3.02 HANDLING FACILITIES

A. LIFTING

Transformers shall be provided with permanently fitted lifting lugs or eye bolts to facilitate handling by crane or hoist.

Transformers shall be equipped with jacking points to facilitate the removal and or insulation pads.

The bottom supporting steel work shall be fitted with holes or have lugs attached for the attachment of hauling apparatus.

B. FRAME WHEELS

Transformers shall be designed for floor mounting and be provided with removable bi-directional or steerable rollers.

The rollers shall be lockable or means provided to prevent movement of the transformers after Installation

## 3.03 CONNECTION FACILITIES

A. CONNECTION METHODS

Connection methods shall comply with IEC 60076 Provision shall be made by the manufacturer for the mounting and connection of cable boxes and/or bus bars as specified for the HV and LV conductor connections.

Where HV and LV cable boxes and/or bus bars are specified these shall generally be arranged on opposite sides of the transformer. However exact positions shall suit the specified requirements of each individual situation.

LV cable terminations shall be kept separate from the HV cable connections and insulated to the specified voltage and able to withstand the specified short circuit currents.

All HV coil interconnections shall be insulated for the specified voltage, and able to withstand the specified short circuit currents.

An earthing terminal shall be provided at a convenient point on the supporting steel work. All steel work shall be bonded to the earthing terminal if it is not electrically continuous. Provision shall be made for making an earth connection to the neutral of the LV windings, should this be required.

B. TERMINAL MARKINGS

HV and LV winding terminals shall be clearly marked with characters in accordance with IEC 60076.

The characters shall be stamped or engraved on securely fixed, durable and non-corrodible plates.

## 3.04 TAP CHANGING FACILITIES

A. TAP CONNECTIONS AND LINKS

Each transformer shall be provided with tapping on the HV winding to cater for supply voltage

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variations in the range +2.5% and + 5% in compliance with IEC 60076.

Tap changing shall be effected by off-circuit tapping links.

A visible warning notice shall be fixed adjacent to the tapping links and worded as follows:

| |
|---|
| "WARNING - OFF LOAD TAP CHANGING LINKS – ISOLATE HV AND LV SUPPLIES TO TRANSFORMER BEFORE OPERATION" |

## 3.05 THERMAL PROTECTION

Each transformer shall be provided with a system of thermal protection and temperature monitoring.

Temperature sensing thermistors shall be mounted in each LV coil as close as practicable to its hot spot. The thermistors shall be wired back to an electronic controller fitted on the transformer.

The thermistors shall be used to indicate winding temperature, and provide alarm and trip indications, and to operate forced cooling fans and trip HV circuit breakers where specified. Volt-free contacts shall be provided for relaying signals to remote equipment.

Wiring from the thermistors to the temperature controller shall be carried out with single core copper cables to DIN/VDE standards with LEF insulation. Cables shall be contained in galvanized steel conduit supported from the transformer steel work.

The temperatures at which the cooling fans shall be switched on and off shall be adjustable within preset limits.

The power supply for the cooling fans shall be provided from the particular transformer via a suitably fused switch. This switch shall bear the inscription in yellow letters on a black background:

| |
|---|
| "WARNING - SUPPLY FOR TRANSFORMER COOLING FANS - DO NOT SWITCH OFF‖ |

The starter assembly for the cooling fans shall comply with this Specification. A warning label shall be fixed adjacent to the main isolating switch bearing the inscription:

| |
|---|
| "WARNING - SUPPLY FOR TRANSFORMER COOLING FANS - DO NOT SWITCH OFF‖ |

## 3.06 RATING PLATES

Rating plates shall be fitted complying with IEC 60076-11

## 3.07 FOLLOW-UP SERVICE

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A. VOLTAGE MONITORING AND ADJUSTING:

Perform the following voltage monitoring after substantial Completion but not more than six months after Final Acceptance.:

1. During a period of normal load cycles, perform seven days of continuous three phase voltage recording at secondary terminals of each transformer. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective actions, as appropriate.
   a. Adjust transformer taps.
   b. Prepare written request for voltage adjustment by electric utility.
3. Retest: After corrective actions have been performed repeat monitoring until satisfactory results are obtained.
4. Report: Prepare written report covering monitoring and corrective actions performed.

## 3.08 TESTING INSPECTION AND COMMISSIONING

The tests to be carried out in accordance to IEC 60076-11 and in presence of owner's consultant and owner at factory. Test report shall be provided and shall include but not necessarily be limited to:

A. VISUAL AND MECHANICAL INSPECTION

1. Inspect physical and mechanical condition including evidence of moisture and corona.
2. Inspect anchorage, alignment, and grounding.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Verify that control and alarm settings on temperature indicators are as specified.
6. Verify that cooling fans operate.
7. Inspect bolted electrical connections for high resistance using one of the following methods:
   - Use of low-resistance ohmmeter
   - Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
   - Perform thermo graphic survey.
8. Perform specific inspections and mechanical tests as recommended by manufacturer.
9. Perform as-left tests.
10. Verify that as-left tap connections are as specified.

11. Verify the presence of surge arresters.

B. ELECTRICAL TESTS

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

2. Perform insulation-resistance tests winding and each winding ground with test voltage. Calculate polarization index.

3. Perform power-factor or dissipation-factor tests in accordance with the test equipment manufacturer's published data.

4. Perform a power-factor or dissipation-factor tip-up test.

5. Perform turns-ratio tests at the designated tap position.

6. Perform an excitation-current test on each phase.

7. Measure the resistance of each winding at the designated position.

8. Measure core insulation-resistance at 500 volts dc if core is insulated and if the core ground strap is removable.

9. Perform an over potential test on all high- and low-voltage windings-to-ground. See ANSI/IEEE C57.12.91, Sections 10.2 and 10.9.

10. Verify correct secondary voltage phase and phase neutral after energization and prior to loading.

C. TEST VALUES

1. Compare bolted connection resistances to values of similar connections.

2. Bolt-torque levels should be in accordance with Table 10.12 unless otherwise specified by manufacturer.

3. Micro ohm or mV drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate any values which deviate from similar connections by more than 50 percent of the lowest value.

4. Insulation-resistance test values at one minute should be in accordance with Table 10.5.

5. The polarization index shall be compared to previously obtained results and should not be less than 1.0.

6. Turns-ratio test results should not deviate more than one half percent from either the adjacent coils or the calculated ratio.

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7. CH and CL power-factor or dissipation-factor values will vary due to support insulators and bus work utilized on dry transformers. The following should be expected on CHL power factors:

   - Distribution transformers: 5.0 percent or less
   - Consult transformer manufacturers or test equipment manufacturer's data for additional information.

8. Tip-up test watts loss values should indicate no significant increase in power factor.

9. Temperature corrected winding-resistance test results should compare within one percent of previously obtained results.

10. Typical excitation current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.

11. Core insulation-resistance values should be comparable to previously obtained results but not less than one mega ohm at 500 volts DC.

12. AC over potential test shall not exceed 65 percent of factory test voltage for one minute duration. DC over potential test shall not exceed 100 percent of the AC r.m.s test voltage specified in ANSI C57.12.91, Section 10.2 for one minute duration. The insulation should withstand the over potential test voltage applied.

D. Site Tests

All site tests shall be carried out in accordance with this Specification.

After delivery to site each transformer shall be inspected in the presence of the Owner's consultant, prior to installation.

After installation on properly prepared foundations each transformer shall be tested and inspected in the presence of the Owner's consultant.

The HV and LV winding connections shall be demonstrated as providing the specified polarity and phase rotation and tap connections.

The HV and LV windings shall be tested for continuity and insulation resistance with a 1000v insulation tester. The insulation resistance between adjacent windings shall not be less than 100 M ohm.

After the HV windings are energized, it shall be demonstrated that the voltage and phase rotation at the LV terminals are as specified.

## 3.09 PARTICULAR REQUIREMENT – ACCESS

The specified transformers are located as indicated on the drawings.

This places restrictions on the transformers' physical dimensions in case it is necessary to remove/replace a transformer once the installation is handed over and in use.

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The Contractor shall demonstrate to the Owner's consultant that the manufacturer's transformer type selected could be removed/replaced (without incurring builders work) with access through the proposed location.

If required by the Owner's consultant, detailed dimensioned drawings proving removal/replacement is practical shall be provided.

## TECHNICAL REQUIREMENTS / SCHEDULE

| | |
|---|---|
| HV Supply System | 11000V |
| Number of phases | 3 phase |
| System neutral | not applicable |
| Fault level (nominal design) | 500 MVA |
| LV Supply System | 415V |
| No-load voltage | 3 phase |
| Number of phases | 4 wire |
| Rating | 1600 kVA |
| Supply Frequency (HZ) | 50 HZ |
| HV winding connection | Delta |

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| | |
|---|---|
| LV winding connection | Star |
| Vector group reference | DYn 11 |
| Impedance at 75° C | 6% |
| HV Tapping (% of no-loads volts) | ±2.5 %, 0%, -5% & -7.5% |
| Method of cooling | (ANAF) Air Natural + Air Forced ventilation for at least 40% extra rating |
| Secondary voltage at: | |
| Full load | 300 V |
| No load | 415 V |
| Rated Voltage | 11000 V / 415/230V |
| HV Insulation Level | 12 KV 1.1 KV |
| Impulse KV Peak | 95 BIL - |
| Power Frequency (KV RMS) | 28 KV 3 KV |

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| | |
|---|---|
| Paint finish color | Manufacturer Standard |
| HV conductor and type | Top entry XLPE Cables |
| LV conductor and type | Top entry bus-way/Cables |
| Indoor or outdoor<br>Installation/space limitations | Indoor - refer to layout drawing |
| Coil material (HV) | Aluminum or Copper |
| Coil material (LV) | Aluminum or Copper |

# MEDIUM VOLTAGE SWITCHGEAR

# MEDIUM VOLTAGE SWITCHGEAR

## 1. GENERAL

### 1.1. DESCRIPTION

a) This section of Specification defines the technical requirements for Medium voltage (MV) indoor air-insulated metal-clad switchgear and accessories.

b) The works shall comprise the manufacture's, routine testing at manufacture's premises, supply and delivery to site, installation, testing and commissioning at site of MV switchgear equipment specified herein.

c) All items of accessories, fittings, sundries, apparatus or labour whether specified in detail or not but which in the opinion of the Engineer are usual or necessary for the satisfactory completion of the project shall form part of the work.

d) The complete Medium Voltage Switchgear installation shall be engineering, manufacture to Local Authority's specification and acceptance. The Contractor shall arrange whatever required to satisfy Local Authority's takeover requirement.

### 1.2. SERVICE CONDITION

All components of the switch panel shall be manufactured to be used indoors under the following conditions without the need for dehumidifiers or space heaters.

A maximum switch room temperature of 50°C and an average switch room temperature of 35°C.

A mean relative humidity of 80%, the maximum being 100%.

### 1.3. STANDARDS

All plant items shall be manufactured and tested generally in accordance with the following standards:

| Item | | Standard |
|---|---|---|
| 1. | Circuit Breakers | IEC 56-1 to 56-6,IEC298, IEC 267, IEC 62271-100 |
| 2. | Jointing Devices | IEC 139 |
| 3. | Earthing Devices | IEC 129, BS 5253 |
| 4. | Isolating Devices | IEC 129, BS 5253 |
| 5. | Current Transformers | BS 3938, IEC 60044-1 |
| 6. | Voltage Transformers | BS 3941, IEC 60044-2 |
| 7. | Insulators | BS 223 |
| 8. | Protective System | BS 3950 |
| 9. | Relays | BS 142 |
| 10. | Instruments | BS 89 |
| 11. | Earthing | BS7430 |
| 12. | Current Ratings | IEC 59 |
| 13. | Insulating Oil | BS 148 |
| 14. | Medium Voltage Test Technique | IEC 60, BS 923 |
| 15. | Transformers | BS 171 |
| 16. | Annealed Copper For Cable Conductors | BS 6360, IEC 228 |

| | | |
|---|---|---|
| 17. | Determination Of Current Ratings of Power Cables | IEC 287 |
| 18. | Fuse Switches | IEC 265 |
| 19. | Oil Switches | BS 5463 |
| 20. | Motors | BS500 Pt 10,11and 99 |
| 21. | Motor Starter & Control Gear | BS 5-124 Pt 1 |
| 22. | Wires And Wiring | BS 6231 |
| 23. | Galvanizing | BS 729 |

BS/IEC or other National Standards not mentioned above but are applicable to the installation shall also apply.

If the specification conflict in any way with any or all of the above standards, the specifications shall have precedence and shall govern.

Where deviation from the above standards is minor, the approval of the Engineer may be given to the use of other national or international standards prevalent in the country of manufacture. No departure from the standards specified will be considered after the Contract has been awarded unless specific authorization has been granted by the Engineer.

Where the number of the IEC or BS standard is not specifically stated above, the IEC or BS standard used shall be one most appropriate to the class of equipment, material or work done specified by the Contractor.

## 1.4. SUBMITTAL

Upon the request of the Engineer, the Contractor shall submit reports issued by a national or international testing authority on Type Tests, which have been successfully performed on the switchgear offered. The Engineer reserves the right to reject switchgear for non-compliance with this requirement.

The Type Test shall be performed in accordance with the relevant standards mentioned above and shall include:

1. Mechanical tests on circuit breaker in accordance with BS 5 3 11 Part 4.
2. Mechanical tests on disconnections and earthing switches in accordance with BS 5253.
3. Temperature rise and mill volt drop tests in accordance with IEC 298.
4. Impulse withstands voltage tests in accordance with BS 5311, BS 5253 and IEC 298.
5. Power frequency voltage tests in accordance with BS 5311, BS 5253 and IEC 298.
6. Short circuit making and breaking tests in accordance with BS 5311. Where circuit breakers having a critical current of less than 10% of the short circuit breaking current. critical current test shall be made in accordance to BS 5311.
7. Short-time current tests in accordance with BS 5311.
8. Cable charging current breaking tests in accordance with BS 5311.
9. Small inductive current breaking tests.
10. Arcing due to internal fault in accordance with IEC 517 and IEC 298.
11. Peak short circuit current tests in accordance with BS 5253.
12. Verification of degree of protection in accordance with IEC 529.

Should modifications be made to the manufacturing on the switchgear which may affect any or all the performance obtained from type tests already completed, the relevant type tests shall be repeated at the expense of the Contractor. As a minimum, the following shall be submitted for the

Engineer's approval at appropriate stages of the works.

1. Detailed schedule of equipment, components and manufacturers data including time-current curves for each type of relay.
2. Detailed switchboard construction drawings to show the bus bar arrangement, panel layout, etc.
3. Electrical control wiring diagrams showing details of all wiring internal and external to the switchboard. together with terminal numbers for cable termination.
4. Setting levels of all adjustable tripping devices.
5. Equipment weight.
6. Builders work requirements.
7. Maximum heat dissipation from the switchboard.
8. Schedule of labels, inscriptions and colors.
9. Surface treatment of the switchboard.
10. Testing procedures and report format for testing of switchboard at the manufacturers works and on site.

Upon the request of the Engineer, the Contractor shall submit the following documents. The Engineer reserves the right to reject switchgear work for non-compliance with these requirements.

02 sets of shop drawings for preliminary checking of the Consultant.

02 sets of final approved shop drawings for the Client record.

01 set of catalogue/ literature relevant with material require for the complete installation, testing and commissioning of the Job.

02 sets of As-built drawing for preliminary checking of the Consultant.

04 sets of final approved as-built drawing + 01 No CD (soft copy on auto cad) for the Client record.

Site test reports

Testing and commissioning procedures.

Operation & maintenance manuals/ procedures.

The Contractor shall be responsible for ensuring protection discrimination will be maintained throughout the MV and the LV electrical systems and shall submit for approval recommended relay settings, supported by fault calculations, for all protective equipment being supplied.

## 1.5. SHOP DRAWINGS

The shop drawing submittals shall include, but not be limited to, the following:

a) Dimensioned drawings of metal enclosed switchgear showing accurately scaled basic units including, but not necessarily limited to, auxiliary compartments, unit components, combination units, bus bar chambers, outline dimensions, top & bottom views showing entry and exit spaces for conduits and front & side elevations showing arrangement of all devices.

b) Total full weight of unit.

c) Single-line diagram.

d) Schematics and wiring diagrams for metering and controls.

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e) Instrument transformer data

f) Coordination curves for each type and rating of vacuum circuit breaker.

g) Arc flash calculation to determine the energy/heat available during short circuit conditions.

h) Furnish, upon request, manufacturer's product data of metal enclosed switchgear and all related components.

i) Test Reports for VCB and all other components.

j) Installation procedures.

k) Operation and Maintenance Manuals.

## 2. PRODUCT

### 2.01 RATING AND PERFORMANCE

The intended operating voltage of the switchgear is shown on the Specification Drawings.

### 2.02 PRIMARY COMPONENTS

The ratings of primary components have the following values unless otherwise specified.

| | |
|---|---|
| Operation Voltage | 11 kV |
| Rated frequency | 50 Hz |
| Rated voltage | 12 kVrms |
| One min. power frequency | 28 kVrms |
| Impulse withstand voltage | 95 kVpeak |
| Rated short time current /duration | 31 kA/1sec. |
| Rated 15 min DC withstand voltage of parts directly connected to power cables | 20 kVdc |
| Visible or audible corona (between one phase and all other phases to earth) | None with Switchgear energised at 30 kV |

a) Circuit Breaker

In addition to the ratings specified for primary components, the circuit breakers shall be rated in accordance with BS 5311 except as otherwise specified.

| | | |
|---|---|---|
| a. | Operation Voltage | 11 kV |
| b. | Rated operating sequence | 0-3min-CO-3min-CO |
| c. | Rated short circuit making current | 50 kA peak |
| d. | Rated AC component short circuit breaking current | 31 kA/1sec. |
| e. | TRV peak value for terminal faults at rated short circuit breaking current, Uc | 20.6 kV peak |
| f. | Time coordinate t3 | 60 us |
| g. | Time delay td | 9 us |
| h. | Voltage co-ordinate | 6.9 kV |
| i. | Time co-ordinate t' | 29 us |
| j. | Rate of rise Uc/t'3 | 0.45 kV/us |

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All values for rated transient recovery voltage shall be in accordance with BS 5311. representation by 2 parameters, first-pole-to-clear factor = 1.5. Representation of rated TRV to be in accordance with BS 5311.

b) Current Transformer

In addition to the ratings specified for primary components, current transformers shall be rated in accordance with BS 3938 and as follows.

1. Current transformers for IDMTL over current protection and earth fault protection.

| | 11 kV switchgear |
|---|---|
| Class | 5P20 |
| Burden | 15 VA |

Tenant transformer over current and balanced earth fault protection (for transformer panel)

| Overcurrent and balanced earth fault protection CT earth fault protection CT (for transformer panel) | 11 kV switchgear |
|---|---|
| Class | X |
| Rated ratio | 200/100/5A |
| Rated knee Point voltage at max. secondary turns | > 100 V |
| Max. exciting current at rated knee point voltage | < 250 mA |
| Max. resistance of the secondary winding corrected to 75°C | < 0.08 Ohm |

2. Current transformers for tariff metering

| | |
|---|---|
| Class | 0.5 |
| Rated ratio | 200/100/5A |
| Burden | 15 VA |

3. Voltage Transformer

In addition to the ratings specified for primary components, voltage transformers shall be rated in accordance with BS 3941 and as follows:

| | 11 kV switchgear |
|---|---|
| Class designation | 1.0 |
| Rated output per phase for star- connected VTs per phase for star- connected VTs | 100 VA |
| Rated output per phase for V- connected VTs per phase for V- connected VTs | 180 VA |
| Rated ratio | As shown on Drawings |
| Voltage factor | 1.5 times rated voltage |

## 2.03 SWITCHGEAR CONSTRUCTIONAL FEATURES

a) The switchgear shall be of the indoor, metal-clad detail as defined in IEC 298. The switchgear shall be of three-phase equipment comprising the busbars, a circuit breaker/fuse switch, current transformers, voltage transformers. protective relays, auxiliary relays, complete wiring and other necessary accessories whether specified in detail or not.

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b) The busbars, circuit breaker, fuse switch. current transformers cable terminals and voltage transformer of a switch panel shall be segregated from one another by means of separate compartments.
c) Protective relays, auxiliary relays and control devices shall be mounted in easily accessible position.
d) The switch panels shall be so manufactured that an extension panel can be put into position, cabled up and made ready before making dead the existing busbars. When extending either end of a switchboard, it shall not be necessary to interfere with the busbars or other components of existing switch panels except opening of the busbar and cover for the connection to be made and connecting tip of the secondary wiring.
e) The various compartments of the switchgear shall be so arranged that in the event of water accumulating on the switchroom floor, there shall be no danger of water penetrating into compartments housing active components e.g. busbars, relays etc.

## 2.04 TYPE AND RATING

a) The switchgear shall be indoor, having a degree of protection of IP 5X, floor mounted, extensible metal clad detail suitable for service at the rated voltage and tested in accordance with BS 5311 certified by A.S.T.A., K.E.M.A. or other approved international Testing Authority and acceptable to Local Authority of Tripoli, Libya. Type test reports shall be submitted upon request.
b) The switchgear shall be capable of withstanding as a whole, without damage the electrical, mechanical and thermal stresses produced under short circuit conditions equivalent to 500 MVA at 11,000 volt 3 seconds as defined in BS 5311.

## 2.05 INSULATION

a) Non-tracking and non hygroscopic solid insulant of cast epoxy resin or equivalent shall be used for the insulation of the busbars, busbar to circuit breaker connectors, circuit breaker isolating contact orifices, circuit breaker to cable box connectors, primary conductor of current transformers and voltage transformers.
b) Post insulators of cast epoxy resin or equivalent material shall comply with IEC 272 and with these specifications, and shall be type and routine tested to IEC 660.
c) The insulated components shall be rigidly mounted in alt- and where appropriate graded Insulation in the form of condenser bushings shall be used.
d) Where individual poles are provided for the circuit breakers, these shall be encased in and mounted on bushings of solid insulant specified above.
e) All five conductors shall be fully insulated throughout their lengths and joints.
f) it shall not be possible for any personnel to be in contact with any exposed solid insulant in the course of their ordinary duties when the switchboard is energised.

## 2.06 BUSBARS AND CONNECTORS

a) Busbars and connectors shall be of electrolytic copper and the conductors for the busbars and the various connectors shall be of electrolytic copper, adequately dimensioned for the normal current and short-circuit ratings in accordance to BS 159. As a minimum, all busbars shall be silver plated or electro-tinned at joints.
b) Connection of busbars between panels shall be made without the necessity of loose interconnection links. The fixed (orifice) and movable isolating contacts of the panel and circuit breaker respectively shall be silver-plated to provide good conductivity. Busbar end covers shall be accommodated inside an end switch panel without the necessity of an additional panel space.
c) The detail of the joint between lengths of busbars and those from the busbars and connectors to other components of the switch-ear equipment shall be such as to permit easy dismantling. Busbars and connectors shall be insulated. The conductor shall be rigidly supported by solid insulators.
d) Busbar shall be colour coded for the phase identification and shall conform to the phase sequence R-Y-B.

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## 2.07 CIRCUIT BREAKERS

Circuit Breakers shall be of vacuum type and shall be mounted on a carriage with wheels for location with the fixed portion of the switch panel. The carriage shall be provided with the necessary orifice shutter operating mechanism, earthing contacts, secondary circuit plugs and other devices required for the safe operation of the circuit breaker.

a) Circuit Breaker Contacts

1. Circuit Breaker contacts shall be of adequate dimensions to cater for the rated normal current and short circuit currents of the circuit breaker.

2. The normal current carrying contacts shall be of copper shall and be silvered plated. Either the fixed or moving contact shall comprise of spring loaded multi-finger segments with self-aligning features. Arcing contacts shall be tipped with tungsten or equivalent material to minimise deterioration during arcing.

3. The contacts shall be arranged to ensure that the arcing contacts make before the main current contact in a closing operation and break after the main current carrying contacts in an opening operation.

b) Arc Control Device

1. Each break of a circuit breaker shall be provided with an arc control device of an approved detail which will ensure high speed are extinction and adequate control of pressure during current breaking operations.

2. Excessive over voltages shall be limited by the manufacturer detail and careful consideration shall be given to the switching of small inductive current and cable charging current.

c) Operation Mechanism

1. The circuit breaker operating mechanism shall be manufactured for high speed opening and closing of circuit breaker under all operating conditions. All mechanical parts shall be adequately sized to ensure consistent operation of the mechanism when subjected to force due to heavy short-circuit currents. The operating mechanism shall be such that the maximum difference between the instances of contacts separating during opening shall not exceed one tenth of a cycle of rated frequency.

2. It shall be possible to lubricate and service the moving parts of the mechanism without dismantling major components.

3. All important operation procedures of the switchgear shall be stenciled on an approved place (to be finalized upon award of tender).

4. The operating mechanism for the circuit breaker shall be "trip free" as define in BS5311.

d) Closing Mechanism

1. Closing mechanisms for the circuit breakers shall be one of the following versions. Spring operated power closing mechanism for closing a circuit breaker by means of energy which has been previously stored in a motor charged spring, with electrical release. For this version of closing mechanism:

   a. It shall not be possible for the circuit breaker to close whilst the closing spring is being charged.

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b. It shall be necessary for the spring to be fully charged before it can be released to close the circuit breaker.

c. The mechanisms shall be so arranged to ensure that the circuit breaker shall always open at normal operating speed even if the mechanism fails to latch on closing.

d. It shall be possible to charge the spring with the circuit breaker in the closed position and if the spring is released the circuit breaker shall not open.

e. A visual mechanical indicating device shall be provided to indicate the state of the spring and inscribed "SPRING CHARGED" when the mechanism is in the position to close the circuit breaker and "SPRING FREE" when it is in any other condition.

2. Mechanisms shall be provided with means for charging the spring by hand. A safety feature should be incorporated in the electrical circuitry of the spring motor charging such that when the charging handle is inserted in the manual charging entry. AC supply to the motor charging is automatically cut off so that it is not possible to motor charging the spring at the same time. The circuitry should be restored to normal after the charging handle is removed.

e) Tripping Mechanisms

1. Tripping of the circuit breaker shall be by means of a spring or springs charged up during the closing operation.

2. Each mechanism shall be provided with a shunt release and the necessary auxiliarv switches.

3. A counter shall be fitted to the mechanism of each equipment, arrange to summate all "opening" operation of the interrupter.

4. Means shall be provided for the local manual tripping of the circuit breaker, preferably by push button. shrouded to avoid inadvertent operation.

5. Facilities shall be provided for locking off the manual tripping of the circuit breaker.

6. It shall not be possible to gain access to the tripping toggle or any part of the mechanism which would permit defeat of the locking of the manual tripping.

f) Mechanism Control

1. Mechanisms shall be provided with the following control facilities:

a. Remote electrical closing-release and trip with selection at the circuit breaker.

b. Local electrical closing-release and trip with selection at the circuit breaker.

c. Local manual closing release and trip preferably by push buttons shrouded to prevent inadvertent operation.

d. Automatic re-charging of the spring after the completion of a closing operation, with a control switch on each panel to cut off the AC supply so as to disconnect this facility.

e. An auxiliary switch shall be provided to give remote indication of "Spring-Charted" status.

g) Selector And Control Switches On Switchgear

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1. Selector switches shall be of the two-position type (i.e. on. off and neutral position) with facilities for locking in both the local and remote positions.

2. Control switches shall be arranged to return automatically to the neutral position when the handle is released after being turned to either the" close" or "trip" positions. Sequence devices shall not be fitted.

h) Position Indicators

1. The following are the minimum position indicators that shall be provided on the switchgear:
   a. Spring Charged
   b. Spring Free
   c. Circuit breaker "ON"
   d. Circuit breaker "OFF"
   e. Earth "ON"
   f. Earth "OFF"

2. All above indicators shall be operated through mechanical means subjected to the approval of Engineer. Additional electrical indicator lamps (LED type) showing the status (e.g. circuit breaker "ON" or "OFF") shall be provided on the front of the switch panel. Supply to these electrical indicators shall be fed from the battery charger through an independent circuit.

i) Circuit Breaker Auxiliary Switches

1. Auxiliary switches shall be positively driven in both directions. They shall be mounted so as to be readily accessible for maintenance and shall be manufacturered to facilitate inspection, cleaning and adjustment.

2. A sufficient number of auxiliary switches shall be provided on each circuit breaker for the various control and indication functions.

j) Circuit Breaker Isolation

1. Circuit Breakers shall be the horizontally isolated withdrawable version. A horizontally isolated circuit breaker shall be provided with racking handles where necessary for ease of insertion or withdrawal of the circuit breaker.

2. Isolating contacts shall be of the multi-fingers self-aligning detail and shall be silver-plated.

3. When the circuit breaker is in the service position, the orifices shall be sealed to prevent any ingress of dust to the fixed contacts.

k) Orifice Safety Shutters

1. A set of shutters shall be provided to cover each three-phase group of stationary isolating contacts. The shutters shall open and close automatically by a positive drive

2. The shutters shall be automatically in closed position when the circuit breaker is in the following position:

   a. Disconnected Position
   b. Test Position
   c. Removed Position (Maintenance Position)

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3. For circuit breakers with integral method of earthing, the shutters for unearthed stationary isolating contact shall be in closed position when the circuit breaker is in earthed position.

4. Busbar shutters shall be painted "Signal Red" colour 537 in-BS 381C and shall be clearly labelled "BUSBAR' in large white letters. Circuit shutters shall be painted "Lemon" colour 355 in BS 391C. Circuit shutters shall not be lettered.

5. On bus-section panels both sets of shutter shall be painted "Signal Red" colour 537 in BS 331 C and labeled "BUSBAR' in large white letters. In addition, an arrow shall be painted in white on each shutter of bus-section units. This arrow shall point towards the section of busbar with which the shutter is associated.

6. The mounting, of the shutters shall be so manufactured that it is not possible to interchange the busbar and circuit shutters.

l) Circuit Breaker Location

1. For switchgear panels provided with circuit earthing facilities through the circuit breaker, it shall be possible to locate the circuit breaker in the following positions:

   a. Service Position

   b. Disconnected Position or Test Position

2. For switch panels provided with quick-acting fault making earthing switches for the circuit the following positions are required:

   a. Service position

   b. Disconnected position

   c. Test position

   d. Removed position (maintenance position)

   e. Earthed position

3. It shall be possible to leave the circuit breaker within the switchgear compartment in the disconnected, test and earth position and have the panel door in closed position. If quick-acting-fault-making switch is used. be it in earthed on opened position, the circuit breaker shall be able to be left in disconnected/test position with the door closed.

4. Indication of circuit breaker location shall be at the front of the switch panel and shall be an approved mean.

## 2.08 CIRCUIT EARTHING

a) Each switch panel shall be arranged to permit earthing of the circuit side of the equipment.
b) The earthing equipment shall form an integral part of each switch panel without loose accessories being required.
c) Earthing shall be carried out by either one of the following methods:

1. Through the circuit breaker after it has been transferred to the appropriate earthing location within its compartment.

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2. By means of three phase quick acting fault acting earthing switches instead on the circuit side of each switch panel. The switches shall be closed by manual charged spring.

3. Earthing which requires the use of separate earthing truck (or equipment of similar nature) is not acceptable.

d) Busbar earthing is not required.

## 2.09 INTERLOCKS_

A. Each switch panel shall be provided with complete inter-locking facilities to prevent any dangerous or undesirable operation.

B. The interlocks may be mechanical, electrical or a combination of both types.

C. The following shall be the minimum interlocks provided: Interlocks to prevented:

1. A closed breaker from being withdrawal from or inserted into the isolating contacts.

2. A, circuit breaker from being inserted into its service position or positions when its pole parts or tank are not in their proper position.

3. The closing of a circuit breaker unless it is in service isolated, or earthed position or when it is completely withdrawn from its compartment. Tripping by attempted isolation.

D. A circuit breaker from being advertently located or removed from a selected earth location.

E. Closing of circuit or busbar earthing switches on a panel unless the circuit breaker is isolated.

F. Where they are required by the switchgear manufacturing detail, other interlocks shall be provided for safe operation of the switchgears.

G. The overall arrangement of the switchgear shall be such that all the circuit breakers can be clearly seen to be isolated before the earthing switch is closed.

## 2.10 CURRENT TRANSFORMERS

A. Current transformers shall be of the bar primary type. The primary conductor shall be insulated in accordance with this Specification.

B. The current transformers shall be mounted either on their own chamber in the fixed portion of the switch panel on be circuit side or alternatively they may be mounted in a chamber on the withdrawn circuit breaker.

C. The current transformers shall be mounted in air over condenser bushings where necessary. If these are on the circuit breaker, special precautions shall be taken to ensure good connection of the secondary leads to the protective relays on the fixed portion of the switch-gear. An interlock shall be provided to prevent the circuit breakers being put into service when the secondary leads are not correctly or effectively connected to the relays. When the current transformers are disconnected from the relays, their secondary leads shall be automatically shorted out.

D. The number of current transformers per phase for the various types of switch panels shall be in accordance with the Specification. Sufficient space shall be provided in the current transformer chamber for the accommodation of at least three current transformers per phase whether all three are in fact specified for the individual switch panels.

E. The complete manufacturing detail of the CTs inclusive of the mounting shall be such that PI tests can be carried out at site without the need to dismantle the CTs from the switchgear.

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## 2.11 VOLTAGE TRANSFORMERS

A. The primary windings of the voltage transformers shall be insulated in accordance with this Specification.

B. Voltage transformers shall be mounted in air on the circuit side of the switch panel in their own compartments and shall be within the zone of the circuit protective system. They shall be housed in a separate compartment.

C. The voltage transformers shall be protected by Medium voltage HRC fuses.

D. The secondary winding of a voltage transformer shall be protected from external short circuits by miniature circuit breaker (MCB)).

E. HT fuses shall be provided on the primary side to isolate the voltage transformer for the purpose of power frequency voltage withstand test on the circuit breaker and also to enable DC pressure test to be carried out on terminated power cables.

F. All components of the voltage transformers shall be rated for system short-circuit capacity and insulation level.

G. Tenderers shall submit drawings showing the detailed mounting and location of the voltage transformers and its components.

## 2.12 CABLE TERMINATION

A. Each switch panel shall be provided with a cable connection compartment for the termination of power cables supplied under the Contract.

B. The cable connection compartment shall also be for control cable and shall be provided with each switch panel as required. They shall be suitable for the termination of control cables supplied in the contract.

## 2.13 NEON POTENTIAL INDICATORS

A. Each switch panel cable shall be provided with three phase neon potential indicators which will show whether the cable is electrically energised.

## 2.14 SWITCHGEAR METAL ENCLOSURES

A. Switchgear metal enclosures shall be of robust construction and shall be manufacturered to prevent the ingress of vermin. Metal panels shall be provided with seals of non-rust material to keep out dust likely to be present in switch room.

B. Each metal panel shall be reinforced with cross members so that the panel cubicle is rigid and will not distort under short circuit conditions.

## 2.15 PROTECTIVE RELAYS

A. Relays shall comply with the requirements of BS 142 and be of GEC or Reyrolle manufacturer or equivalent.

B. Relay elements shall be accommodated in either of the following manners:

1. On racks of standard dimensions in which case the elements, racks and auxiliary items shall be housed in dust-proof and vermin proof compartments and transparent front covers shall be provided.

2. In dust-proof draw out type cases. The relays shall be mounted in a manner to provide access to their wiring terminals.

C. Circuits and components used for the relays shall as far as possible be standardized and in the event of a fault, components shall be easily replaceable. All parts of the relays shall be

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fully treated to withstand the temperature and humidity conditions likely to be encountered in Tripoli, Libya.

D. When relay elements performing a plural number of functions are installed in a common case, each function shall be provided with its own flag indicator to enable the type of fault condition to be identified. Each indicator shall be capable of being reset by hand without opening the relay case. Each indicator shall be so manufactured that it cannot be operated before the relay has completed its function.

E. All relays shall be suitably marked with the following information:

1. Function of relay (e.g. over current)
2. Phase
3. Characteristic: curve where appropriate
4. Rated current or voltage
5. Rated making capacity of contacts

F. Markings shall be visible from the front of the relay without removing the cover.

G. In order to minimize the effect of electrolysis, flag indicator coils and D.C relay operating coils shall be so placed in the circuit that they are connected to the positive pole of operating battery except through contacts which are normally open but shall preferably be directly connected to the negative supply.

H. All relays shall, except where otherwise approved, be provided with contacts for controlling double tripping circuits for use when two circuit breakers are to be opened simultaneously and for any other interlocking or alarm purposes which may be required.

## 2.16 AUXILIARY RELAYS

A. All auxiliary relays and switches for tripping alarm, indication and control functions shall be of a robust construction. Constructional features shall comply generally with the relevant Specification. Additional spare contacts for remote indication purposes and other functions shall be supplied.

B. All D.C equipment shall be suitable for operation at the existing D.C voltage and shall operate satisfactorily between the limits of 20 percent below and 10 percent above normal operating voltage and over its complete range of operating temperature.

## 2.17 AUXILIARY SWTICHES, FUSES AND MINATURE CIRCUIT BREAKERS

A. Auxiliary control switches for circuit breakers shall be of the pistol grip or other approved type and shall be arranged to operate in one direction when closing the circuit breakers and in the opposite direction when opening them.

B. The control switches shall be so manufactured as to prevent them from being operated inadvertently and shall be so interlocked that after having once been moved to the "close" position they cannot again be moved to that position without first passing through the "open" position. Approved means shall be provided for locking the control switches when they are in the "neutral" position. A label shall be fixed adjacent to the control switch to indicate the name or distinguishing number of the circuit concerned. The control switch shall be so manufactured that when released by the operator it shall return automatically to the neutral position after having been turned to the "closed" position, and shall at the same time interrupt the supply of current to the operating mechanism of the circuit breaker.

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C. Fuses or miniature circuit breaker of an approved type shall be supplied with all voltage transformer secondary circuits. D.C circuits and motor supply circuits.

D. The fuses and miniature circuit breakers shall be of a robust construction and installed at a convenient position within the panels for easy access and identification. Each breaker shall be provided with auxiliary spare contacts for remote indication purposes. When fuses are employed auxiliary relays for the same purpose shall be provided. Miniature circuit breakers shall be provided for the motor and switch position indication circuits

## 2.18 INDICATING INSTRUMENTS

A. All indicating instruments shall be to BS 89 Industrial Grade, and shall be of an approved type. They shall be of the deadbeat type and of approved make and sizes and shall be capable of carrying their full load currents continuously without undue heating. They shall have long clearly divided and indelibly marked circular scales extending over an angle not less than 90' and the pointers shall be of clean outline.

B. The points and scales shall be approved. The marking on the dials shall be restricted to the scale marking. Instruments connected to double ratio current transformers shall be provided with reversible scales. In addition to instantaneous indicators, ammeters shall be provided with half-hour maximum demand indicator. Instrument transformer ratios, makers‘ names, BS Grade, etc. shall not appear on the dials, but shall marked in an approved position.

C. The instruments shall not be damaged by the passage of fault currents through the primary of their corresponding current transformers, and approved means shall be provided for zero adjustment, without dismantling the instrument. The scale of all direct current instruments shall be arranged so that the instruments will read 10 percent of the full scale reading and this part of the scale shall be marked in red. In duo-directional circuits, however, centre zero instruments or displaced zero instruments will a changeover switch shall be employed as approved.

D. All voltmeters and ammeters shall be mounted at the front of the switch panels at convenient position.

## 2.19 SECONDARY WIRING AND CABLE

A. All secondary wiring for the switchgear, relays, instruments, cubicles etc. shall have approved insulation of PVC to BS 6231 of 600 volt grade.

B. Unless otherwise approved, all wiring shall have a conductor size of not less than 2.5 $mm^2$ tinned copper.

C. All wiring shall be neatly run and groups of wires shall be securely fixed by cleats so that wiring can be checked without the necessity of removing the cleats. The cleats shall be made from moulded insulating material or no-rust metal. Wiring between fixed and moving portions of the switch panel shall be run in no-rust flexible tubes. The wires and flexible tubes shall be mounted to obviate any damage to them when the circuits are moved.

D. Each wire shall be terminated with either the "Rose Courtney" or crimped type of terminal stud; and number by an approved type of interlocking ferrules. Ferrules shall be of an approved type of preferably white and shall be provided with a glossy finish to prevent staining. Ferrules shall be clearly and durably marked in black and shall not be affected by damp or oil. All wires associated with tripping circuits shall have red ferrules marked "Trip". Wires shall not be jointed or reed between terminal joints.

E. Bus wires shall be fully and separately installed along the top or bottom of the relay, alarm and control compartments. Means shall be provided to enable all circuits in the cubicle, except the lighting circuit, to be isolated from the bus wires.

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F. Wherever practical all circuits. in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The working voltage of each circuit shall be marked on the associated terminal boards.

G. The D.C trip supplies, closing supplies, A.C supplies, wiring to the different protective system etc. shall be segregated from each other. Each such group where required and appropriate shall be fed through separate fuses or miniature circuit breakers from the bus wires. There shall not be more than one set of supplies to the apparatus to each group.

H. The clearance between relay stems or connecting studs shall not be less than 2.5 cm unless otherwise approved.

I. Resistance shall be provided with stud terminals. Set screws shall not be used. Wiring diagrams for control and relay circuits shall preferably be drawn as if viewed from the back and it shall be clearly stated on each diagram which view is employed. They shall show the terminal boards arranged as in service.

J. Control cables shall be PVC insulated and shall be of 600 volt grade comply with BS 6231. Wire conductors shall be at least 2.5 $mm^2$ tinned copper unless otherwise approved.

K. Multicore tails shall be so bound that each wire may be traced without difficulty to its associated cable.

L. The spare cores of all multi-core cables shall be numbered and terminated at the top of a terminal block in the panel. Where cables are terminate in a junction box and the connections to a relay or other instruments are continued in conduit an approved number of spare cores shall be taken through the conduit and terminated in the cubicle.

M. Screen cables shall be used and the screens of screened pairs of multi-core cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagrams.

## 2.20 TERMINAL BOARDS

A. Terminal boards shall be provided with stud terminals for incoming and outgoing wires and not more than two wires shall be connected to any one terminal. Insulating barriers shall be provided between adjacent connectors. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals.

B. Covers of transparent insulated material shall be provided on all terminal boards. Labels shall he provided on the fixed portion of the terminal boards. Terminal board studs shall not be numbered. No live metal shall be exposed at the back of the terminal boards. Unless otherwise approved terminal boards shall not be used as junction points for wires which are not required in the associated panel.

## 2.21 TEST FACILITIES

A. The switchgear shall be provided with facilities for:

1. The Medium voltage testing of the insulation of its primary components and power cables connected to the switchgear. This shall include AC pressure testing of equipment, DC pressure and insulation testing (via insulation tester) of cables.

2. The primary injection testing of all current transformers.

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3. Means to place phasing out components at the termination end for the purpose of core identification in the course of work (e.g. cable diversion) without the need to dismantle the terminated cable.

## 2.22 SECONDARY TESTING FACILITIES

A. Testing facilities in all current transformer secondary circuits shall be incorporated in the protective relays of the draw-out type as specified in the relevant Clauses of the Specification and suitable for the insertion of portable test pugs for the purpose of checking all components within a relay.

B. Secondary circuit earthing points shall be connected via a test link for the purpose of checking the insulation resistance of all circuits.

C. Testing facilities for metering current and voltage transformers shall be as specified in the relevant Clauses of the Specification.

D. All test terminals shall be easily accessible without having to dismantle any part of the switchgear.

E. Any testing accessories/test plug that are necessary to facilitate the above mentioned testing shall be considered to be included in the contract price and adequate sets shall be supplied.

## 2.23 MOTOR

A. Unless otherwise approved, motor shall be of the squirrel cage screen protected type. The motors shall be suitable for a three phase 400 volts 50 Hz supply. They shall be suitable for direct starting at full voltage without the use of star-delta switches, autotransformer starters, or starting resistance. The motors shall comply with BS 2613 and shall be continuously rated unless otherwise specified. The motors shall be supplied by an approved manufacturer.

B. The motor shall operate at all loads without undue vibration and with the least amount of noise.

C. The starting current at full voltage shall not exceed six times full load current. The starting current shall be determined by a locked rotor test and if this is carried out at reduced voltage it shall be made with not less than full load stator current and the starting current at full voltage shall be taken as the current measured at reduced voltage increased to the ratio of the full voltage to the reduced voltage. No tolerance shall be applied when tested in this manner.

D. The motor windings shall be insulated with Class 'E' insulating material defined by British Standards or to approval. The stator coils after assembly in the slots shall be dried by heating and afterwards impregnated by dipping in insulating composition so as to render the windings non-hygroscopic and solid in structure.

E. The outside of all end coils shall be coated with oil resisting non-hygroscopic varnish or compound and the coils shall be supported as to prevent movement under shock. The insulation and impregnation of end winding shall be such that the coils can be readily removed and replaced.

F. The rotor and stator shall be skewed relatively to each other

G. The rotor winding construction shall be manufactured to minimize the possibility of conductors breading and all joints shall be made by means of electrical bring or in other approved manner so as to prevent all possibility of their working loose.

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H. Unless otherwise approved all motors shall have ball or roller bearings and motors of vertical spindle type shall have approved thrust bearings.

I. Bearings shall be fitted with hexagon nipples for grease lubrication to BS 1486

J. All motors of the vertical spindle type shall be provided with a substantial canopy of approved detail.

K. Motor terminals shall be of the stud type. totally enclosed and to approval. They shall be substantially manufactured and thoroughly insulated from the frames. Cambric or other

L. Approved insulation shall be used for connections for the windings to the terminals.

M. Each motor shall be fitted with a terminal box either suitable for screwed conduit entry or provided with an approved cable box as may be specified.

N. If a cable box is specified it shall be provided with all necessary fittings, including a filling plug, an air vent hole, of approved capacity, a brass wiping gland and for wire armoured cable, for combined armour and earthing clamp. The gland plate shall not be split and a removable front cover shall be provided.

O. Each motor shall be equipped with three pole control gear suitable for the direct starting by the switching of full line voltage on to a standing motor.

## 2.24 CONTACTOR

A. Contactors shall be of robust construction and shall operate without undue noise or vibration. Contactor operated from a D.C supply shall comply with the relevant Clause. All contactors shall be suitable for the direct starting of motors by the switching of full line voltage on to a standing motor.

B. Contactors shall be mounted in ventilated metal cubicles of an approved type. The ventilating openings shall be provided with close mesh guarding with holes not exceeding 2.5 mm. The metal surfaces of the cubicle walls adjacent to the contactors shall be protected by fireproof insulating materials unless otherwise approved. Where two or more contactors are contained in the same cubicle they shall be separated by barriers of fireproof insulating materials. All bare copper connections shall be taped and all secondary wiring shall be arranged and protected as to prevent it being damaged by arcing.

C. All motors, contactors and their associated apparatus must be capable of holding in and operating satisfactorily and without overheating for a period of ten minutes if the supply voltage falls for that period to 70 percent of the normal value at normal frequency. The motor contactors and associated apparatus shall be capable of operation with a supply voltage of 85 percent of the normal value and at normal frequency.

D. All terminals shall comply with the Specifications.

## 2.25 EARTHING OF NON-ELECTRICAL PARTS

A. All parts of the switchgear metal enclosure, metal cases of relays and instruments, cable glands and all other non-electrical metal work on the switchgear shall be connected to a sub-station earth terminal by means of a main and auxiliary earth bars.

B. The earthing system shall be such as to ensure:

1. That the potential of the conductors of the systems are maintained at a level consistent with the insulation levels applied.

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2. Low resistance is provided for the flow of fault currents to achieve fast and definite operation of protection relays, and

3. The appearance of dangerous voltages on metalwork to which a man has legitimate access under normal and abnormal conditions is prevented.

C. The size of the main and auxiliary copper earth bars shall be selected in accordance with recommendations contained in BS7430, taking into consideration the short time current rating, of the switchgear in the switch room.

D. Earthing requirements shall be generally in accordance with BS7430.

E. Earth electrodes shall be insulated in accordance with recommendations contained in BS7430.

## 2.26 SUPPORTING STRUCTURES

A. The contractor shall provide any rails, beams, frames or structures required for supporting the switchgear panels, control panels, battery units etc. on the concrete floor of the switch room.

B. All detachable switchgear metal frames shall be galvanized and fastened with stainless steel bolts and nuts. Screws shall not be allowed for such purpose.

## 2.27 PANEL LIGHTING

A. If the manufacturing of the switch panels are such that normal switchroom lighting is inadequate for work on the equipment, panel lighting shall be provided together with all miniature circuit breakers, control switches etc.

## 2.28 SWITCHBOARD BATTERY UNITS

A. Each MV switchboard shall be provided with a charger and battery unit.

B. The battery shall have the capability to trip four switchgear panels simultaneously for at least 20 times (this must be verified by calculations). When sizing the AH capacity of the battery, the effect of ageing shall be taken into consideration.

C. The AH capacity of the battery supplied shall be greater than the calculated AH requirement, but shall not be less than 20 AH. Every if the calculated AH requirement is less than 20 AH, the battery must still be rated at 20 AH.

D. The charger shall have sufficient capacity to restore a depleted battery to 80% full capacity in less than 8 hours.

E. Only the tripping coil and the closing coil shall be connected to the battery unit. Other load such as filament lamps shall be taken from a separate rectifier or from an AC source through a step down transformer.

F. The charger and battery unit shall be suitably accommodated in a steel cabinet. The cabinet shall be suitable for floor mounting. The charger and battery compartments shall be accessible from the front of the cabinet by means of hinged doors.

## 2.29 A.C/D.C Control PANEL

A. For the switchboard with motor charged spring closing mechanism, motor raised circuit breaker mechanisms or lighting circuit, a main A.C. panel shall be provided for the control of all the A.C circuits.

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B. The panel shall be suitably rated for the size of the switchboard.

C. The panel shall be an ON-OFF switch with fuse protection with suitable terminals for an incoming supply lead and outgoing bus wires to the switchboard.

D. The A.C control panel may be accommodated in the existing cabinet if this is possible.

E. For each switchboard a main AC panel with suitable rating MCBs and terminals for an incoming supply lead and outgoing bus wires to the switchboard shall be provided.

F. The AC control panel may be accommodated in the same cabinet as the controls for the battery charger. All outgoing circuits e.g. DC control circuits, motor charging circuit, etc. shall be protected by miniature circuit breakers. A spare outgoing AC sub-circuit controlled by MCB shall be incorporated in the battery charger unit.

G. The function of each MCB shall be clearly indicated and the labeling shall be riveted to the enclosure. A spare outgoing DC circuit shall be provided at each battery charger unit and the labeling of its function to be carried out by the Contractor.

## 2.30 CONNECTING CABLES

A. Connecting cables between the switchboard and battery unit, and between the switchboard and AC control panel shall be neatly run on cable trays supplied by the Contractors.

B. The connecting cables between the switchboard and battery unit shall be at least 4 mm in size and shall be run in a ring configuration. Physically, the cables for entry and exit of the same loop should not be the same. All wiring and termination of connecting cables shall be carried out by the Contractor. Conductors used for AC and DC circuits shall not be mixed in the same multi-conductor cable.

## 2.31 CONTRACTORS STAFF

A. The contractor shall provide properly qualified installation and commissioning personnel and a sufficient number of properly qualified erectors to carry out the work. The erection commissioning personnel and erector shall be subject to Engineer's approval. The contractor shall, upon the request of the Engineer, remove any erection and commissioning personnel or erector who, in the Engineer's opinion, is incompetent or has been conducting himself improperly and shall replace the commissioning personnel or erector so removed with another acceptable to the Engineer.

B. The erection and commissioning personnel shall represent the contractor on the site and directions given to him shall be deemed to be given to the contractor. It is the contractor's responsibility to provide efficient and continuous supervision of the work at site.

# 3. EARTHING INSTALLATION

## 3.01 GENERAL

A. A complete earthing system comprising cables, conduit tapes. earth electrodes and earth connections necessary elective and permanent bonding to earth the non-current carrying

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metal work of all the switchgear and ancillary apparatus under this Contract shall be supplied, erected and connected under this section of the Specification.

## 3.02 CODE OF PRACTICE

A. The earthing of the whole installation shall comply with the current standard - Earthing, issued by the British Standards and the Wiring of Electrical Equipment of Buildings BS7671 and BS7430 respectively.

## 3.03 INSTALLATION

A. The main switchboard shall be earthed to the earthing termination by means of a stranded copper. PVC insulated earthing conductor drawn in a 75 mm diameter underground cable duct. The installation of the main earthing shall be of green colour.

B. Earthing tapes shall be of copper and shall be run in approved positions and fixed in approved manner using FURSE No. 44 general saddles of appropriate size for securing tapes at intervals not exceeding 1 meter. Tapes shall be supplied in continuous unbroken lengths, as far as practicable, to avoid unnecessary jointing. Mating surfaces of all tapes at joints, etc. shall be tinned, riveted and soldered. Joints in exposed sections shall be protected against corrosion and ingress of moisture by the application of at least two coats of approved anti corrosion paint.

C. Each connection of all sections of the installation shall be electrically continuous throughout.

D. Connections to electrical apparatus shall be made by a bolted connection in a visible and accessible position. Consideration shall be given so that dissimilar and incompatible metals are not directly in contact but have a high conductivity non reacting barrier between them.

E. The earthing system includes for measuring, marking off, cutting, fitting, erection, testing, supply of necessary tools and materials for fixing, jointing, etc. including consumable stores.

## 3.04 EARTHING POINTS

A. Earthing points shall be provided according to specification Section 30.

## 3.05 EARTH LEADS

A. The minimum size of the earth leads shall comply with those specified in the current edition of the "Institution of Electrical Engineers Regulations for the Electrical Equipment Building", unless otherwise specified in this Specification and Standards BS7430.

B. Aluminium conductors are not permitted for the purpose of this Contract. All earth leads shall be copper conductors of the appropriate cross-section.

## 3.06 EARTHING PIT

A. Earthing pit shall be provided according to relevant specification section.

## 3.07 EARTH VALUE

A. The Tender Price shall be deemed to include all necessary equipment, instrument, materials, labor, transportation etc. in connection with the system of earthing points and interconnections thereof to obtain the required earth resistance value of less than ONE ohm.

## 3.08 TEST RECORD

A. The results of all testing of earthing electrodes shall be recorded together with the dates of the tests and shall be kept by the contractor for inspection whenever required by the Engineer.

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B. The record shall be handed over upon completion of the Contract.

### 3.09 EVIDENCE OF SUPPLY RECORD

A. The switchgear supplier shall produce evidence of sound supply record with the Local Authority or other major developments in Tripoli, Libya for the past five years.

## 4. PROTECTIVE SYSTEMS

### 4.01 TYPE

A. The protective systems to be provided with the switchgear shall be as follows:

1. Feed
   a. Pilot wire-Solkor R.
   b. IDMTL over current and earth fault.

2. Transformer panels
   a. IDMTL over current and balanced earth Fault.
   b. Winding and oil temperature.

### 4.02 SETTING AND PERFORMANCE

A. The pilot wire protective system shall operate in conjunction with similar equipment at the remote end of the feeder via pilot cable. The pilot cables used will be 1 x 10 pairs, 1.5 mm 2, copper conductor, polyethylene insulated, copper tape screened, polyethylene over sheathed, steel wire tape armoured and PVC outer sheathed.

## 5. SWITCHROOM AUXILIARY ITEMS

A. The Contractor shall supply, deliver and install the following ancillary items:
1. Framed single line diagram.
2. First aid chart.
3. Approved rubber mat extending to the full length of the switchboard.
4. Key cabinet to accommodate keys and sub-station logbook.
5. A4-size logbook.
6. Danger signage on all equipment, sub-station doors etc.
7. Operating tool board.

## 6. SCHEDULE OF TESTS FOR MV SWITCHGEARS

Certified copies of the type test reports of the same type and make of switchgears as that supplied under this Contract shall be submitted.

### 6.01 TYPE TESTS

A. The following Type or Tests shall be made on the switchgears

1. No Load Operations Before Short Circuit Tests
   Closing and opening operations shall be made on one circuit breaker of each type in accordance with IEC 56.4. Electrical opening and closing devices shall be energised at voltages specified in IEC 56.4.

2. Basic Short-circuit Test Duties
   Short circuit closing and opening tests consisting the following test duties shall be made on one circuit breaker of each type in accordance with IEC 56.4:

   a. Test-duty No. 1: O-3 min. CO-3 min.-CO at 10% rated short-circuit

breaking current with a DC component of less than 20% of the AC component and transient and power frequency recovery voltages as specified in of IEC 56.4.

b. Test-duty No. 2: O-3 min. CO-3 min.-CO at 30% rated short-circuit breaking current with a DC component of less than 20% of the AC component and transient and power frequency recovery voltages as specified in IEC 56.4.

c. Test-duty No. 3: O-3 min. CO-3 min.-CO at 6090 rated short-circuit breaking current with a DC component of less than 20% of the AC component and transient and power frequency recovery voltage as specified in IEC 56.4.

d. Test-duty No. 4: O-3 min. CO-3 min.-CO at 100% of the rated. short-circuit breaking current with a DC of less than 20% of the AC component and taking into account IEC 56.4 and with transient and power frequency recovery voltages as specified in IEC 56.4

e. Test-duty No. 5: O- min. CO-3 min.-CO at 100% rated short-circuit Breaking current with a DC component equal to the appropriate value specified in 56.2 and a transient and power frequency recovery voltage as specified in IEC 56.4 and IEC 56.2.

3. Critical Current Tests
   a. Where circuit breakers have a critical current of less than 10% of the rated short-circuit breaking current critical current tests in accordance with IEC 56.4 shall be made.
4. Small Inductive Current Breaking Tests
   a. Small inductive current breaking tests shall be made on one circuit breaker of each type to demonstrate that the circuit breakers are capable of breaking small inductive currents up to rated value without excessive over voltages.
5. Cable Charging. Current Breaking Tests
   a. Cable charging Current Breaking tests shall be made on one circuit breaker of each type in accordance with IEC 56.4 to demonstrate that the circuit breakers are capable of breaking cable charging up to rated value without excessive over voltages. The test duties shall be those specified in IEC 56.4 and as follows:

| Test-duty No | Supply Circuit IEC 56.4 | Test current as percentage of the rated cable charging breaking current |
|---|---|---|
| 1 | 1 | 20 to 40 |
| 2 | 1 | 100 to 110 |
| 3 | 2 | 20 to 40 |
| 4 | 2 | 100 to 110 |

6. Short Time Current Tests
   a. One unit of each primary component with a rated short-time current (i.e. circuit breaker, disconnecting isolators, earthing switches, busbars, current transformers,

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cable sealing ends) shall be short-time current tested at its rated short-time current for its rated duration of short-circuit in accordance with the appropriate IEC or BS.

7. Peak Short-circuit Current Tests On Isolating Devices And Earthing Switches

   a. One isolating device and one earthing switch of each type shall be subjected to a test to prove its capability of carrying the rated peak short-circuit current in accordance with IEC 129.

8. Short-circuit Making Tests On Earthing Switches

   a. One earthing switch of each type shall be subjected to a test to prove its rated short-circuit making current in accordance with IEC 129.

9. Voltage Division Test

   a. Voltage division across the different units of a multiple break circuit breaker shall be determined under short circuit conditions. The method of measurement of the division of power frequency recovery and transient recovery voltages across the individual breaks shall be in accordance with IEC

10. Mechanical Tests

    a. One circuit breaker of each type shall be subjected to the mechanical test specified in IEC 56.4. The test shall consist of 1000 operating cycles without voltage or current in the primary circuit.

    b. Mechanical tests on isolating devices and earthing switches shall be made on one unit of each in accordance with IEC 129.

11. Temperature Rise And mV Drop Test

    a. Temperature Rise and mV Drop Tests shall be made in accordance with the appropriate standards and as follows:

| | | | |
|---|---|---|---|
| 1) | Circuit breakers | : | IEC 564 |
| 2) | Disconnecting isolators and earthing switches | : | IEC129 |
| 3) | Busbars | : | IEC 56.4 |
| 4) | Current transformers | : | BS 3938 |
| 5) | Voltage transformers | : | BS 3941 |
| 6) | Cable Sealing, Ends where applicable | : | IEC 56.4 |

12. Impulse Withstand Voltage Tests

    a. At least one unit of each type of primary component be tested at the rated impulse withstand voltage in accordance with the method specified in IEC 56.4 and IEC 60.

13. Power Frequency Withstand Voltage Tests

    a. At least one unit of each type of primary component shall be tested for one minute at the rated power frequency withstand voltage in accordance with IEC 56. IEC 129 and IEC 60.

14. Tests On Current And Voltage Transformers

    a. Current and voltage transformer shall be fully tested to BS 3935 and 3941 respectively.

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15. Tests On Protective Equipment
    a. All protective systems and relays shall be fully performed tested to BS 3950 and BS 142.

16. Tests On Relays
    a. All relays shall be type tested to BS 142.
17. Test On Instruments
    a. Instruments shall be type tested to BS 89.
18. Test On Motors
    a. One motor of each type shall be type tested in accordance with BS 2613, BS 170 and BS 3739 where appropriate.
19. Test On Motor Starters And Control Gear
    a. Motor starters and control gear shall be type tested to BS 775.
20. Test On Secondarv Wires And Control Cables
    a. Secondary wires and control cables shall be type tested BS 6231.
21. Power Frequency Withstand Voltage Tests
    a. All primary components of the switchgear except the voltage transformer shall be tested for one minute at the rated power frequency withstand voltage in accordance with IEC 56.4 and IEC 60. This test shall be made with the various components of the switch-ear assembled and ready for dispatch.
22. Millivolt Drop Test
    a. Millivolt drop test shall be carried out on all contacts and terminals of primary components for comparison with millivolt drop type test stated in.
23. Mechanical Operating Tests
    a. All circuit breakers shall be subjected to the mechanical operating tests specified in BS 56.4. All isolating devices and earthing switches shall be . subjected to the mechanical operating tests specified in IEC 129.
24. Test On Current and Voltage Transformers The following tests shall be carried out Current Transformers
    a. Power frequency withstand voltage test on secondary winding in accordance with BS 3938.
    b. Over-voltage intertum tests in accordance with BS 3938.
    c. Verification of Terminal markings shall be made in accordance BS 3938.

25. Voltage Transformers
    a. Tests to determine voltage and phase errors in accordance with BS 3941.
26. Test On Relavs
    a. Each relay shall be routine tested in accordance with BS 142.
27. Test On Instruments
    a. Each instrument shall be routine tested in accordance with BS 89.
28. Tests On Motors
    a. Each motor shall be routine tested in accordance with BS 2613.
29. Test On Motor Starters And Control gear
    a. Each apparatus shall be routine tested in accordance with BS 775.
30. Tests On Secondary Wires Control Cables And Circuits
    a. All wires and cables shall be routine tested to BS 6231 shall be made on the continuity and correctness of all wiring before any item is dispatched from the factor.
31. Test On Interlocks
    a. Each system of interlocks shall be checked as installed in service to prove that it will prevent any dangerous or undesirable operation of the main plant items.

## 6.02 SAMPLES TEST

A. The following sample tests shall be made on the switchgear materials.
    1. Tests On Solid Insulators
        a. Samples of solid insulators for the switchgear shall be selected for tests to prove

compliance with requirements in their electrical and mechanical properties.

2. Galvanizing Tests
   a. Samples selected by the Engineer of all galvanized materials shall be subjected to the galvanizing tests of BS 443 or BS 729 whichever is applicable.
3. Tests On Seals
   a. Samples of seals used for the switchgear enclosure shall be tested for their no deteriorating properties.

## 6.03 QUALITY CONTROL TESTS

A. The Contractor shall establish a quality assurance scheme during the manufacture of the switchgear to ensure that the quality of the product leaving the factory is high and all defects in manufacture are eliminated. This scheme shall be additional to the Routine and Sample Tests specified.

B. The scheme shall cover the assurance of the quality of materials. methods of welding,. casting, molding, forging etc., fabrication and assembly and the final testing and inspection of the finished product.

C. The Contractor shall include the cost of the requirement for witness at manufacturer for Factory Acceptance Test (FAT) not limited to Quality Control Tests, Routine and sample tests specified for the Engineer and Employer representative – 2 persons 3 day (excluding transport time) for tests at USA embassy rate.

## 6.04 SITE TESTS AUTHORISED TESTING ENGINEERING

A. The following tests shall be made on site during erection and completion of switchgear

1. Site Stage Tests

   a. Tests on Current-Carrying & Earthing Connections

      1) All primary conductors and conductors used for the earthing system shall be tested to ensure full clamping pressure is applied to all contact surface and that all bolted connections are tightly secured with lock washers. Flexible connections shall be tested to ensure that sufficient slack is available for expansion.

   b. Tests On Secondary Wiring And Circuits
      1) All wiring shall be checked against wiring diagrams provided by the Contractor and approved by the Engineer. Tests shall be made to ensure the continuity of each wire.
   c. Operation Tests
      1) The operation of trip and closing devices, Mechanism Motors, etc. shall be checked.
   d. Battery Tests
      1) Battery units shall be checked and tested for correct output voltage and proper functioning of equipment.
   e. AC Control Panel Tests
      1) The AC control panel for motors, lighting etc. shall be checked for proper operation.

2. Commissioning Tests
   a. After the erection of the switchgear and its auxiliary items have been completed. the following commissioning tests shall be made.
      1) Operation Tests

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The circuit breakers, isolating devices and earthing switches shall be operated electrically and manually where appropriate.

2) Power Frequency Voltage withstand Tests
The completed switchgear shall be subjected to a power frequency voltage withstand test of the specified voltage for one minute in accordance with the test method specified in IEC 56. IEC 129 and IEC 60.
3) Primary Current Injection Tests On Protective Systems
All protective systems shall be tested for correct current transformer ratio, polarity and relay operation by the primary current injection method.
4) Secondary Current Injection Tests on Relays
Relays shall be tested for accuracy and compliance with BS 142 requirements by the secondary current injection method.
5) Secondary Wiring Tests
The insulation of the secondary wires and circuits shall be checked with an insulation tester.

3. Relay Operation And Tripping Tests

a. All relays shall be operated to assure the correct tripping of circuit breakers.

1) Test On Interlocks
The correct operation of the interlocks shall be checked. The Contractor shall conduct all the tests required by the Engineer and the relevant Authorities. Where the tests are to be carried out by the Local Authority the Contractor shall make all necessary arrangement to conduct the tests and any costs to be incurred shall be deemed to have been included in the Contract.

## 7. LABELLING

A. All switchgear panels shall be appropriately labeled to indicate the circuit they serve. The Contractor shall submit these labels to the Engineer for approval.

B. Labels to identify the circuits shall be fitted both at the front and back of the switchgear panel and on doors or other detachable panels and circuit breakers

C. Labels shall be of white plastic, engraved with black letters and/or figures or vice versa and be of an approved size, and attached to the equipment with self-tapping screws. Use of adhesive is not acceptable.

# MEDIUM VOLTAGE CABLES

# MEDIUM VOLTAGE CABLES

## 1. GENERAL

### SCOPE OF WORK

This section specifies the engineering, supply and installation of MV power cables, manufactured to the latest revision of IEC 502 and appropriate BS/EN.

The indicative routing of the major MV cables are shown on the Drawings. The Contractor shall be responsible for co-ordination with Local Authority, to determine the exact routes and quantities of the MV cable installation. The MV cable installation shall comply with Local Authority's requirement.

The Works shall include the supply and installation of all cable glands, cable lugs, racks, hangers, suitable fire rated cable enclosure if applicable, clamps, cable clips, cable brackets, cable ladders, etc. and the supply of all necessary labors, equipment and materials for laying, termination of power cable.

### STANDARDS

The complete cable shall be engineered to manufacturer data and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC:

| | | |
|---|---|---|
| IEC 228 | : | Conductors of insulated cables |
| IEC 502 | : | Extruded solid dielectric insulated power cables for rated voltages from 1kV up to 30kV |
| IEC 540 | : | Test methods for insulation and sheaths of electric cables and cords (electromeric and phermoplastic compounds) |
| BS 5468 | : | Cross-linked polyethylene insulation of electric cables. |

The engineering of the cable to manufacturer data shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and approval to the Engineer.

In the adoption of standards and requirements, the Contractor shall take the following precedence:

Engineer's decision;

Local codes of practice;

Drawings;

Specifications;

International standards and requirements.

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## SUBMISSION

All technical submissions shall be approved by the Engineers prior to the respective stages of construction.

As a minimum requirement, the submission shall include the following:

Shop drawings of the complete cable routes (including the cable ladder, tray / pipes and cable support system, etc). Cable routes as shown on the Drawings are for general guidance only; no variation will be entertained for cable route subject to adjustment of route and site co-ordination.

Equipment submission and sample submission;

Cable termination details for cable manufacturer;

Cable test reports for routine test, type test, and site acceptance test;

Testing and commissioning procedure of MV cables;

Builders work Requirement.

## CLIMATIC CONDITION

The cables will be used in Lahore re sub-soil salty water exists in depths varying from three feet to eight feet. The climatic and atmospheric condition is given below:-

| | |
|---|---|
| Peak ambient air temperature | 48°C |
| Mean maximum temperature during 24 hours | 35°C |
| Minimum temperature | -1°C |
| Maximum sun temperature on exposed horizontal surface | 52 °C |
| Maximum relative humidity. | 60% at dry-bulb temperature of 47°C |
| Average annual rainfall. | 1000mm. |
| Altitude | _____m above sea-level |
| Location | Gujranwala |

## 2. PRODUCT

## INSULATED CONDUCTORS

The conductor shall be EC grade aluminum as per IEC60228 class 2 stranded conductors.

Conductor Shield – The stranded conductor shall be shielded with an extruded semi conducting layer before insulating

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Insulation: - The insulation shall be cross linked polyethylene. The average thickness of the insulation shall be 4.5mm, which should not be less than 3.95 mm at any one point.

### SHIELDING

The cables core shall be shielded in accordance with the shielding recommendation of IEC 60502 (2005) or applicable publication.

Shielding shall consist of layer of semi conducting XLPE material extruded or semi conducting material coated directly over the insulation and a rubberize semi conducting tape applied over with an overlap of 15% (width of the tape).

The semi conducting insulation shield shall be covered by a bare copper shielding tape applied with an overlap of 15% (width of the tape).

Phase identification shall be obtained by using either colored Tapes (Red Yellow, Blue) which shall be applied over semi-conductor tape longitudinally or numerically 1,2,3 printed on semi-conducting tape in Red, Yellow, Blue colors.

The insulation shield shall be easy to strip from the insulation and individual conductors of multi conductor cables shall be easy to separate for termination purpose.

### ASSEMBLY

Three insulated cores shall then be laid with jute or synthetic fiber filters and bound with a cable tape binder.

The cable tape binder shall then be covered with a PVC Jacket. PVC compound should be compatible with the conductor operating temperature of 90°C. PVC Jacket should have the following nominal radial thickness, subject to a required tolerance of 20% + 2mm.

### ARMOUR

Armoring shall be provided with steel wire. The thickness of each wire shall be 3.15mm for sizes 300mm$^2$ applied helically over the PVC bedding, covering the surface of the bedding. Steel wires shall be in accordance with requirements laid out in BSS 6346:69.

### OVERALL JACKET

The entire cable assembly shall then be covered with a PVC outer jacket suitable for the operating temperature of the cable. Nominal radial thickness shall be as given below and subject to a required tolerance of 20% + 0.2mm.

### PACKING

The cables shall be supplied wound in lengths, as given in below on non-returnable drums which shall be strong enough to withstand transport from the factory and handling on site when laying the cables. Covering, strong enough to withstand the handling shall be put around the circumference of the drum to protect the cable from damage. Relevant brief particulars of the cables shall be painted on the side of the drums as well the identification ―Property of SBP‖.

## 3. EXECUTION

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## LAYING & TERMINATION OF MV CABLES

### GENERAL

In general, the installation of cables shall be carried out in accordance with the latest GEPCO Specifications, manufacturer‘s recommendations and IEE Regulations. The bending radius (as a multiple of the overall cable diameter, $d_0$) shall not be less than

600/ 1000 V PVC cable $12d_0$

6350/ 11000 V XLPE cable $15d_0$

Even during handling, pulling, and installation. A total maximum of 5% of the cable length shall be provided as slack (at termination positions, in draw-pits, etc).

Cables shall generally be laid parallel to roads and footpaths, within the appropriate services reservations. During excavation, laying, and backfilling, the adjacent and intersecting service pipes and runs shall not be damaged or disturbed.

Cable drums shall be carried on suitable trailers and unloaded near point of use. Any rolling shall only be in the direction of the arrow marked on the drum. If hoisting equipment is not available, ramp boards (max 1:4) with a winch or a coil of rope around the drum shall be used. The cable shall be paid out by jacking/propping the drum on an axle/spindle, and a braking plank installed below. Care shall be taken to see that the manufacturers recommended pulling tension is not exceeded. Cable rollers shall be installed at maximum 2m spacing (1.2m for heavy cables) and at bends. A cable stocking or pulling eye shall be attached to the leading edge of the cable for pulling purposes. Cables shall not be laid if the temperature is below 0 °Centigrade.

Power cables shall be installed in cable ducts, directly buried, or in under floor cable trenches, as required.

The following methods shall be employed for laying cables:

Paying out from a trailer

Laying by hand

Laying by motor-driven rollers

Pulling by winches

If cable is to be carried by hand (un-supported by rollers) men shall stand 4 to 6 m apart along the route. Flaking of cables (¯figure-eight method‖) may be employed, taking care to prevent infringement of the minimum bending radius requirement.

For directly buried cable, excavation shall be carried out in accordance with BS6031, and shall be kept free of water and protected against damage or collapse. Before cables are laid, the bottom of the trench shall be graded evenly, cleared of loose stones, and then covered for the full width of the trench with 75mm thick fine riddled-soil/sieved-sand bedding (in compacted 50mm layers). After cables are laid, a 50mm thick sand cover shall be laid over the cable, with 50mm thick protective brick/tiles provided along the entire length. The first layer of backfill shall be placed manually and compacted by hand punning until a thickness of 150 mm over the cover tile is reached. Additional layer shall be laid in 150mm increments and may be compacted mechanically.

When cable trenches are opened all cables shall be laid as quickly as possible. The engineer's approval shall be obtained before a trench is backfilled, but generally backfilling shall be commenced within 24 hours of cable laying and the work completed speedily.

Multi-core cables in pipe and duct shall be pulled after the entire raceway system has been completed, dried out, and cleared of all obstructions, using a wooden mandrel (300mm length, dia. 10mm less than pipe dia) to ensure correct alignment.

After installation of cables in underground ducts and pipes, the cable shall be supported any from the bottom end of the pipe and the pipe and the pipe-ends shall be properly plugged and sealed to prevent ingress of water or vermin.

On completion of laying, terminating and jointing of the cables and CPC, a plan (1:500) shall be prepared, containing the following details:

Type of cables, X-sectional area of conductors, rated voltage.

Year of manufacture, month and year of laying

Actual laid lengths between centers of the joints and between them and the sealing ends.

Exact locations and depths of cables and joints in relation to fixed points.

The electrical values of the completed installation shall be measured and recorded:

Insulation resistance between conductors and between conductors and earth/armour. Conductor resistance, using a suitable measuring bridge of all cores.

Capacitance, between conductors and between conductors and earth/ armour.

Markers of approved design/inscription shall be installed to indicate the location of all joint boxes at every point where a cable enters a building, sub-station, plinth or feeder pillar and will be provided all along the cable route at regular intervals of 30m when a straight run occurs or when the route changes direction. The XLPE cables will terminate with approved stress cone in panels.

Cable markers shall be made of concrete, 600mm square by 100mm thick with impressed characters. They shall be made of grade 20 concrete, with 10mm aggregate. The wording shall be ¯HT CABLE‖, ¯LT CABLE‖ or ¯COMMUNICATION CABLE‖ as appropriate, together with circuit details, as instructed by the Engineer; in addition, the word ¯JOINT‖ shall be added where appropriate.

## 11-kV Power Cable Terminations

The terminations covered are of pre-moulded cold, heat shrinkable and slip on type for indoor and outdoor use, suitable for rapid and easy installation and for maintaining safety of the persons and the equipment. The terminations shall be suitable for operation at the ambient temperature of 50°C. The relative humidity may range up to 100%. The termination kits shall be suitable for a three-phase 11kV distribution system of the following characteristics:

| | |
|---|---|
| Nominal System Voltage | 11 kV |
| System Highest Voltage | 12 kV |
| Frequency | 50 Hz |
| Maximum short circuit rating | 25 kV |

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Indoor termination shall be made in pad mounted steel enclosures and switchgear panels where dust and severe condensation is liable to occur.

The termination kits shall conform to GEPCO specifications.

**11kV Power Cable Splices**

The joint and termination kits shall be suitable for cable of following description:

Single Core Cable

This conductor is of aluminum, covered by a semi-conducting layer approximately 0.25 mm thick.

The conductor insulation is made of cross-linked polyethylene of 4.5 mm thickness applied over semi-conducting layer.

A semi-conducting tape

Layer approximately 0.51 mm thick is applied over the insulation.

A tinned annealed copper foil shielding tape of thickness 0.127 mm is applied helically to the surface of the insulation with an overlap of about 50 percent of the tape width.

An overall polyvinyl chloride sheath of 2mm thickness is applied over the core.

Three Core Cable

This construction of the individual cores of three-core cable shall be the same as for single core cable stated in clause a (i) above except that the overall sheath shall not be applied.

A suitable binding tape shall be applied helically over the laid up cores with a suitable overlap.

The cable shall be covered with an inner jacket made of polyvinyl chloride compound of 2 mm thickness.

A bedding tape of approximately 1mm thickness made of rubberized cotton or jute shall be applied over the inner PVC jacket.

Steel tape armour of 0.75 mm thickness shall be applied over the bedding. The armour shall consist either of two layers of galvanized steel tape or a single layer of interlocked galvanized steel tape.

Overall PVC sheath of approximately 2.8 mm thickness shall be applied over the armour.

The kits supplied for terminations, tee and straight joints shall be suitable for continuous operation at an ambient temperature of maximum 50 °C and for a conductor operating temperature of 90 °C.

Terminations shall be made in pad mounted steel enclosure where severe condensation is liable to occur.

Tee and straight joints shall be suitable for direct burial underground or

Installation in ducts. The duct and soil conditions vary from dry to wet. Highly corrosive salts are encountered in soil.

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The splices and terminations shall be suitable for operation at ambient temperature of 50oC maximum and suitable for three phase underground 11kV distribution system of the following characteristics:

| | |
|---|---|
| Nominal System Voltage | 11 kV |
| System Highest Voltage | 12 kV |
| Frequency | 50 Hz |
| Maximum short circuit rating | 25 kV |

The material kits shall be according to GEPCO'S latest specifications (amended to-date)

Termination Kits

A protective covering of suitable materials having anti-track and erosion-resistant properties for use as an external covering of insulated cores for indoor and outdoor use shall be provided. Where required, sealants may be used to effect seals on joints.

A tube or pre-moulded cone of suitable material having properties to provide electric stress control over insulated cores of the terminations of indoor and outdoor use shall be provided.

Suitable tubing for enclosing and sealing prepared lug for indoor and outdoor terminations shall be provided. The tube shall have anti-track and erosion resistant properties.

The trifurcated tube of suitable material for sealing a prepared crotch (for three core cables) for indoor and outdoor terminations shall be provided. It shall have excellent Water proof and erosion resistant properties.

Rain sheds of suitable material shall be provided for application over prepared outdoor terminations. The material shall have excellent anti-tracking and erosion resistant properties.

The internal surface of the tubular part shall be coated with suitable adhesive compound or provided with adhesive tape for proper fixing of the shed.

Indoor termination shall be provided with Lugs. Outdoor termination shall be provided with Sleeves and Connectors.

All Bolts, Nuts and Spring Washers used in connectors shall be of steel and electrolytically galvanized. The thickness of coating shall be such as to withstand two, one minute's dips in a Copper Sulphate solution.

A suitable copper flexible earthing strap of one meter in length shall be provided for soldering with the metallic shield of the cable. Alternate earthing devices can also be offered for which technical details will be provided.

**Cable Jointing**

Earth joint and termination kit shall contain all materials in adequate amounts necessary to made to splice or termination as per drawings listed above. The approximate quantity of materials to make terminations splices and tee joints. Each splice and termination kit shall contain the following materials

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GEPCO'S specifications:

High voltage splicing tapes.

Pressure sensitive tape (Adhesive tapes) or Glass tape with epoxy resin compound and a brush for applying the compound over the joint.

Semi-conducting tapes.

Tinned coppers mesh tape.

Grounding strap.

Jumper wire or strap.

Cotton tape for binding.

Compression connectors, sleeves or tee joints or lugs as may be the case.

Jointing solder 50: 50.

Soldering flux.

Insulation putty.

Cleaning fluid.

Abrasive cloth.

Cleaning cloth.

The outer coverings of splices and terminations shall be completely non-hygroscopic, moisture and track resistant. This may be achieved by the application of epoxy resin compound over the protective tape.

All connectors shall be filled with inhibiting compound and ends covered with rubber plastic caps. The caps shall fit over the ends tightly to prevent leakage of the compound.

The tape shall consist of an un-vulcanized or partially vulcanized polyethylene base insulating compound with or without synthetic resins and shall be self bonding, self fusing, Ozone and Cornea resistant. The tape shall be suitable for use with cross linked polyethylene, butyl rubber and PVC insulation or a continuous operating temperature of 90 °C.

The characteristics of the insulating tape shall be as follows:

| | |
|---|---|
| Tensile strength min | 17.5 kg/sq cm |
| Elongation at break | 500 % |

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| | |
|---|---|
| Dielectric strength min | 2 KV/mm |
| Volume resistively | 1015 ohm-cm |
| Ozone resistance | No effect when exposed to 0.04% Ozone by volume for 3 hours. |

The tape shall meet the fusion and thickness tests specified in relevant clause of the specification.

The tape shall be wound in rolls with a separator between layers. The separator shall be parchment paper or glazed sheet which shall be interposed between adjacent layers and shall cover the outside of the tape.

The dimensions of the tape shall be as under:

| | |
|---|---|
| Width | 20 mm |
| Thickness minimum | 0.5 mm |
| Length per roll | 10 meters. |

The average thickness shall not vary from the nominal thickness more than 0.075 mm and the average length in any roll shall not be more than 5% from the nominal specified.

Pressure sensitive tapes shall be suitable for providing protective covering over the cable joints and shall be resistant to heat, ozone and moisture. The tape shall be made of plasticized polyvinyl chloride compound or synthetic rubber coated on one side with pressure sensitive adhesives. The tapes shall be suitable for a minimum continuous operating temperature of 70°C. The tape shall be free from sulphur.

The instruction for installation of cable termination kits and cable jointing as contained in GEPCO specification mentioned above may be followed.

## AUTHORITY INCOMING CABLES

The Contractor shall render all assistance to the Local Authority during the laying of the incoming cables.

The Contractor shall provide all termination kits, coordinate with Local Authority and terminate the incoming power and pilot cables at the incoming MV switchboard side.

The Contractor shall provide cable supports for all incoming cables.

## SCHEDULE OF TEST FOR MV CABLES

## FACTORY TESTS

Each type of cable specified shall be fully type tested according to IEC 502 and the appropriate British Standards. The types and sizes of cables required are shown on the Drawings.

Should the Engineer require it, the Contractor shall submit reports issued by a national or international testing authority on type test that have been successfully performed on the cable for his approval.

The type test shall include the following test:

Partial discharge test;

Bending test, plus partial discharge test;

Tan $\delta$ measurement as a function of the voltage and capacitance measurement;

Tan $\delta$ measurement as a function of the temperature;

Heating cycle test plus partial discharge test;

Impulse withstand test, followed by a power frequency voltage test;

Medium-voltage alternating current test;

Type test (non-electrical) as stipulated in IEC 502, Table VI.

Cable routine test shall be conducted at factory in accordance with IEC 502 for the following tests:

Measurement of the electrical resistance of conductors.

Partial discharge test.

4-hour MV test.

## SITE ACCEPTANCE TEST

The Contractor shall supply all necessary testing equipment for site testing. When required, this testing equipment shall be calibrated at the expense of the Contractor at a recognized national laboratory.

The Contractor shall engage an Authorized Medium Voltage Testing Engineer who is recognized by Local Authority to perform all site tests.

In addition to Local Authority's requirements and those recommended by the manufacturer, the following tests shall be carried out:

Continuity test,

Earth test,

Polarity test,

Insulation resistance test,

DC high voltage test. The test voltage shall be in accordance with Local Authority's requirements and Engineer's approval.

# LOW VOLTAGE SWITCHBOARDS / DISTRIBUTION BOARDS

# LOW VOLTAGE SWITCHBOARDS / DISTRIBUTION BOARDS

## 1. GENERAL

### 1.1 Purpose

This section together with its appending document covers the minimum requirement for the design, construction and performance of factory built assemblies of LV switchboard.

### 1.2 Scope of Work

The work under this scope consists of supplying, installation, testing, connecting and commissioning of all material and services of the complete switchboard as specified herein and/ or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with others for exact route, location and positions of electrical lines and equipment.

### 1.3 Standards

Switchboards shall comply with Section ―General Specifications‖, Clause 3.

Particular reference shall be made to:

| | |
|---|---|
| IEC 80000 | Quantities and Units. |
| IEC 60051 | Direct setting electrical measuring instruments. |
| IEC 60073 | Color for indicator lights and push buttons. |
| IEC 61095 | Electromechanical contactors for household and similar purposes. |
| IEC 61869 | Instrument Transformers. |
| IEC 61869-2 | Additional requirements for current transformers. |
| IEC 61869-3 | Additional requirements for inductive voltage transformers. |
| IEC 60269 | Low-voltage fuses. |
| IEC 60439 | Low Voltage switch gear and control gear Assemblies. |
| IEC 60947 | LV Switch gear and Control gear – All Parts (Circuit Breakers, Contactors, Motor Starters, etc.) |
| IEC 60529 | Degree of protection provided by enclosures. |
| IEC 60617 | Graphic symbols for diagrams. |
| BS 951 | Electrical Earthing - Clamps for Earthing & Bonding. |
| BS EN 62305 | Lightning Protection Standard. |
| BS EN 13601 | Copper and copper alloys -Copper rod, bar and wire for general |

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| | |
|---|---|
| | electrical purposes. |
| BS 2874 | Nuts, Bolts, Washers and Rivets for use on copper. |
| BS 6346 | PVC Insulated Cables. |
| BS 7430 | Code of practice for protective earthing of Electrical installations |

Any other standard referred to in above standards or these specifications.

### 1.4 Installation and Service Conditions

For general site conditions refer to Section - E- 1, Clause 4.

Switchboard shall be installed indoor. The equipment shall be capable of operation under the prevailing ambient conditions without any deleterious effect of any kind. Switchboard shall be suitable for continuous operation at full load rating under combined variation of both voltage and frequency as stated in Section - E-1, Clause 5.1.

Transient voltage depression down to 80% of rated voltage shall not affect the performance of the equipment and dip voltage must be within permissible limit.

## 2. MAIN ELECTRICAL CHARACTERISTICS

### 2.1 Power Supply System

Main characteristics of power supply system applicable to all switchboards are:

| | | |
|---|---|---|
| - | Voltage | 400 V $\pm$ 10% |
| - | Phase | 3 $\phi$, 4 Wire. |
| - | Frequency | 50 Hz. $\pm$ 2 Hz. |
| - | Neutral system | solidly grounded. |
| - | Peak asymmetrical SCC | To be specified by the bidders. |
| - | RMS symmetrical SCC | To be specified by the bidders. |

Main characteristics of auxiliary supply system are:

| | | |
|---|---|---|
| - | Control / Command system | 24 VDC. |
| - | Space heater system | 230 VAC. |

### 2.2 Ratings

The equipment shall be capable of carrying the specified current on a continuous basis of 24 hours / day, without exceeding the permitted temperature.

The current ratings of all equipment must be guaranteed at the specified design temperature. Equipment shall be fully rated and constructed for withstanding, making and breaking the specified short circuit duty.

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Pins of auxiliary circuits shall be sized for a rated circuit of 10A Minimum.

## 3. GENERAL REQUIREMENTS

### 3.1 Concept

The Switchboard shall be of standard, prefabricated metal clad cubicle(s), floor mounting type, totally enclosed, dead front, dust tight and vermin proof requiring front access only. It shall complete in all respects with material and accessories, factory assembled, tested and finished all according to the specifications and to normal requirements. For indoor installations the international classification shall be IP42.

The Switchboard with all components and accessories shall be suitable for front operation only and shall:

- have a rated service short service breaking capacity, Ics at 400 VAC, conforming to IEC 60947-2 unless otherwise stated on the drawings.
- be provided with adequate clearance from live parts so that flash over cannot be caused by switching, vermin, pests, etc.
- have all components rated for insulation class 600-volt minimum.
- be designed for flush mounting of all instruments on the front side.
- have all incoming or outgoing connections from the top or bottom as required. Have the components mounted so as to facilitate ease of maintenance from the front. Have common lamp test facility for all lamps.
- have wiring diagram on the inside of door of the switchboard. Be labeled with nameplate on the front side of door.
- have arrangements for extension of switchboard in future.

### 3.2 Accessibility

Switchboard shall preferably be arranged for bottom cable entries. Adequate space must be provided for cable entries and termination. It shall be possible to work easily and safely on cable of a main or control outgoing circuit in OFF position with the remainder of the board alive.

Adequate system shall be provided for installation and clamping of cables inside the cable compartment. Position of terminals and cables shall allow use of clamp ammeter.

Power and Control cable termination shall avoid obstruction to other cable termination and provide easy access for terminating cables. Cable supports shall be provided to avoid undue strain on cable termination. Easily accessible locations shall be reserved in the compartment for measuring transformers.

### 3.3 Heaters

Space heaters shall be provided for prevention of moisture in each cubicle. Heaters shall be wired together and shall be automatically controlled to avoid over heating the equipment. Heater shall be suitable for operation on 230 VAC supply from an external source (to be provide in main Distribution Board)

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### 3.4 Name plates

On the front side, a name plate shall be provided at the top to indicate the name of manufacturer, system voltage and frequency and the current carrying capacity of switchboard.

Each breaker shall have a circuit identification label fitted below the breaker aperture or as suitable.

Drawing indicating the branch circuit names, breaker elements, cable sizes and connecting services shall be placed in a clear plastic pocket provided at the back of the front access.

Labels described shall have block letters 7 mm high on a white back ground, to be made from traffolite and be fixed with screws.

Each incoming and outgoing circuit shall also be labeled with name plate 75 mm x 15 mm, as described above on the front side of door.

## 4. MECHANICAL DESIGN

### 4.1 General Construction

The switchboard shall be fabricated, welded; grinded, finished with angle iron framework and cladded with 14 SWG MS sheet, to form a rigid, free standing, flush mounting fronted assembly.

It shall be suitably divided into panels and compartments for accommodating the required number of circuit components, instruments and accessories. Each compartment shall be fully partitioned from its neighbor both horizontally and vertically, allowing safe cable routing / termination without shutting the switchboard down.

All live parts within cubicles, compartments or modules, which have to accessible during normal maintenance operations, shall be adequately protected and / or barried to ensure protection of works and to avoid accidental contact. Barriers may be rigid, transparent, insulating material fitted with warning labels.

The doors shall be provided with hinges on the left-hand side and locking handles on the right hand side for fastening the door. The front assembly shall be fastened to the enclosure by means of self locating fasteners for quick and easy fixing.

All holes, cutouts shall be tool or jib manufactured and free from burrs and rough edges. All structural components shall be of standardized design to provide complete uniformity and inter change ability of common parts. Removable gland plated shall be provided at top and / or bottom as required.

The switchboard shall be supplied complete with foundation bolts and other installation materials as recommended by the manufacturer. Proper size cable clamping channels with galvanized steel clamps and brass cable clamps respectively for unarmoured and armoured cables shall be provided.

The cabling inside the Switchboard shall be suitably numbered and harnessed by means of straps or cords. Wiring to door mounted components shall be in flexible PVC conduit. All indicating, control and selecting equipment shall be suitably arranged and clearly labeled with indelible labels indicating the rating of fuses, switches, etc.

All metal work of the switchboard shall be cleaned down to bare shining metal, phosphate and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of colour RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 120 microns.

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### 4.2 Bus Bars

Bus bars and droppers supported on non - hygroscopic material are to be high conductivity electrolytic tinned copper, completely isolated and mechanically braced and rated to withstand the specified short circuit currents for one second duration.

Bus bars and droppers shall be housed in a separate compartment and shall be clearly marked with their respective colors. Bus bars shall be provided for three phases, neutral and multi - terminal earth. The temperature rise shall not exceed 50 degree centigrade at rated current. Neutral bus assembly shall consist of outgoing screw terminals with one terminal for every MCCB / MCB.

Neutral Bus bar should be of same ampere rating as phase bar.

Removable metal covers on the bus bar chamber shall be provided with suitably sized labels at regular intervals, fixed with self tapping screws and warning of live metal work.

All bus connectors shall be tinned plated connections and joints. Horizontal bus bars shall be of the same current rating throughout their length.

### 4.3 Earthing

A copper earth bar of suitable section for the specified fault level shall extend the entire length of the Switchboard. Provisions shall be made for possible future extensions at both ends.

Earthing facilities shall be provided on each incoming and outgoing unit to permit earthing of the connections.

All metallic non-current carrying parts of the Switchboard shall be bonded together and connected to the Switchboard's earth bar.

Each circuit wiring shall be green / yellow colour. Earthing mass continuity between withdrawable parts and fixed frame shall be correctly ensured whatever the withdrawable part position.

Provision shall be made adjacent to cable termination for earthing cable armour to the earth bus bar.

Earthing switch shall be provided wherever mandatory as per rules and regulations / codes and standards and shall be manually operated. An interlocking system shall provide the following locking and safety functions:

- Impossibility of closing the earth switch if the switching device is closed.
- Visual check of earthing switch positions to be possible.
- Possibility of locking the earthing switch operating handle in open and closed position.
- The earthing of the bus bar shall be done manually by the operator without provision of general earthing system.

## 5. DISTRIBUTION BOARDS

The enclosure of the LV Distribution Board shall be fabricated from electro-galvanized / zinc coated sheet steel.

The LV Distribution Board shall be fabricated with 16 SWG sheet steel recess mounting. All components shall be installed on a common component mounting plate made of 14 SWG sheet steel

inside the enclosure and protected from the front with screwed sheet steel front plate. The door and dead front covers shall be made of 14 SWG sheet steel. The door shall be fully gasket with hinges on the left hand side and locking handle on the right hand side for fastening the door. The locking handle should be detachable. The dead / front assembly shall be fastened to the enclosure by means of self - locating fasteners for quick and easy fixing.

The distribution board shall be supplied complete with all installation materials as recommended by the manufacturer. The incoming and outgoing cable connections shall be according to the wiring requirements. If required, an adapter box for accommodating the cables and conduits may be provided. The box shall be of the same material and finish as the Distribution Boards.

An earth bar or terminal strips shall be provided for connection of incoming and outgoing earth conductors. The earth bar or terminals shall be permanently connected to the body of Distribution Boards at two points. Flexible copper strip shall be provided for earthing of the door of Distribution Board.

Neutral bus assembly shall consist of out going screw terminals with one terminal for each MCB. All holes, cutouts, etc., shall be tool or jib manufactured and free from burrs and rough edges. Removable gland plates shall be provided at both the top and / or bottom, as required.

The cabling inside the distribution board shall be suitably numbered and harnessed by means of straps or cords. Wiring to door mounted components shall be in flexible PVC conduit. All indicating, control and selecting equipment shall be suitably arranged and clearly labeled with indelible labels indicating the rating of fuses, switches, etc.

All metal work of the distribution board shall be cleaned down to bare shining metal, phosphate and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of color RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 120 microns.

## 6. COMPONENTS

The switchboards shall be provided with all components as specified or shown on the Drawings and as necessary for the satisfactory operation of the Switchboard and of the electrical system. Typical specifications are given here under:

### 6.1 Moulded Case Circuit Breaker

These shall be three pole 400 / 500 volts rating shown on the drawings. The breakers shall have both time delay over current and instantaneous short circuit protection.

The MCCBs shall be installed such that their switching levers are accessible through the dead front plate for operation. Circuit numbers / designation on all circuits shall be conspicuously marked to facilitate connection and maintenance.

The breaker shall have quick make - quick break toggle mechanism with positive 'ON', 'OFF' and intermediate ' Tripped ' positions.

Trip mechanism shall be trip free on overload or short circuit ensuring that the breaker will not close / remain close even if the close command is given while the circuit breaker has tripped due to short circuit or continuing overload.

### 6.2 Miniature Circuit Breaker (MCB)

The MCBs with current rating from 3 to 100 Amps. shall be conforming to BS EN 60-898 or IEC 60947-2. The circuit breakers shall be suitable for DIN-rail mounting, maintenance-free and fully tropicalized.

The MCBs shall be designed for horizontal or vertical mounting, or reverse feeding, without any adverse effect on electrical performance.

The operating mechanism shall be quick make, quick break type, trip free, with all poles opening and closing simultaneously (except for the neutral pole, which if required shall be of the advance-closing and late-opening type). The operating toggle shall clearly indicate the ON and OFF/TRIP positions.

The individual operating mechanism of each pole of a multiple MCB shall be directly linked within the MCB casing and not by the operating handle.

Each pole of the MCBs shall be provided with bimetallic thermal element for overload protection and a magnetic element for short circuit protection.

### 6.3 Residual Current Circuit Breakers (RCCB)

RCCBs shall be four pole, current operated type with tripping current of 0.3A and tripping time not more than 0. I seconds.

### 6.4 Load Break Switch and Contractor

Load Break Switches and contractors shall be of AC3 type for motor loads. Air circuit breakers above 630A shall be housed in separate cubicles. Aluminium plate shall be provided for cable entry to ACBs / MCCBs cubicles of 630A and above rating.

## 7. POWER FACTOR IMPROVEMENT PLANT

The power factor improvement plant shall be used for improving the power factor of the system. The plant shall be automatic-cum-manual.

The power factor improvement plant shall be aligned with main LT switch board and it shall be a part of that LT switchboard as shown on the drawing. The capacitors shall be suitable for three phases, 415 volts 50 Hz system and shall be self cooled, designed for indoor use in tropical climate for maximum ambient temperature of 45 degrees centigrade and relative humidity 90%. The capacitors shall be in the form of banks divided for 12 stages, 6 stages and 4 stages. Each capacitor bank unit shall be 25, 50 and 100 kVAR. The total kVAR capacity shall be as indicated on the drawings. Each capacitor unit shall be complete with discharge resistors and internal fuses and shall be connected with control panel with proper size of single core PVC insulated cables.

The panels shall be supplied complete with a set of 3-phase, full capacity, isolated tinned copper bus bars, interconnections, risers, designation labels, cable sockets, holding down bolts, wiring with cleats and ferrules, earthing sockets and studs, etc. Each control panel shall comprise.

1 No. Multi stage power factor correction relay for automatic/manual control.

1 No. 3-phase, 4 wire, 415 volts, unbalanced load power factor indicator.

Auto-off-Manual selector switch

Current transformer with 5A secondary current, having suitable output burden and accuracy.

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Instrument protection fuses.

Following equipment shall be provided for every 250 KVAR capacitor bank:

1 No. 630 amps, triple pole 415 volts air break contractor with auxiliary contacts (2 N.0+2 NC) Contractor shall be suitable for AC 3 duty.

1 Set of 2 Nos 630 Amps H RC back-up fuses with base and carrier.

1 Set of ON and OFF push buttons.

1 No. Red lamp for ¯On‖ indication of the contractor.

### 7.1 Requirement of Capacitor Banks

According to IEC-83 1 -1 and 831-2.

Fully insulated, terminals to be shielded by a cover.

Dielectric: Plastic poly-propylene, impregnated.

Electrodes: Aluminium coating vacuum metalized.

Safety features: Self healing, Over pressure tear-off fuse.

Withstand switching operations safely.

Maximum in rush current 200 times rated current.

Loading capacity: 1.1 times rated voltage. 1.3 times rated current at delta max.

Overloading capacity 1.5 times rated output at delta max.

Acceptable tolerances - 5/+ 10% of rated output at rated frequency.

Static life expectancy > 100,000 operating hours.

Test Specifications: Terminal versus terminal with an AC voltage 2.15 times rated voltage for 10 seconds duration. Terminals to casing with an AC voltage of 3 KV for 10 seconds duration.

## 8. PARTICULAR COMPONENT REQUIREMENTS

### 8.1 Current Transformers

Current transformers shall comply with the requirements of IEC 60185 (or equivalent).

Current Transformers shall be polyester resin insulated, ring type, air cooled having transformation ratio as indicated on the drawings. The current Transformers shall be of suitable burden having accuracy class 1.0. The Current Transformers shall have rated secondary current 5A / IA as required.

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Current Transformers shall mechanically and thermally withstand the specified short circuit capacity. Test terminal blocks shall be provided for current Transformer secondary circuits having short circuiting provisions to allow portable apparatus to be connected.

## 8.2 Voltage Transformers

Voltage transformers shall comply with the requirements of IEC 60186 (or equivalent) and shall be of the same accuracy class as Current Transformers.

Voltage Transformers shall be equipped with primary fuses with an interrupting capacity of the incoming circuit breakers. Test terminal block shall be provided for each Voltage Transformer system.

## 8.3 Ammeters and Voltmeters

Indicating instruments shall be semi-flush Switchboard type, moving Iron, spring controlled with standard scale having white background and black graduations and markings. The front dimensions shall be 144 x 144 mm for instruments on incoming side and 96 x 96 mm on all outgoing circuits.

Indicating instruments shall be 1.0 class percent of full scale basic accuracy class in accordance with IEC 60051.

The ammeter shall be suitable for connection to 5 Amp. Secondary of Current Transformer or directly through shunt as shown on the drawings. The instruments shall have measuring range indicated on the drawings. A red mark shall be provided at the working voltage on the scale of all voltmeters.

## 8.4 Selector Switches

Ammeter and voltmeter selector switches shall be complete with front plate, grip handle, R-Y-B and OFF position for ammeter and RY-YB-BR-RN and OFF positions for voltmeters.

The selector switches for controls shall be rotary cam type and shall be provided complete with knob and front plate, showing all positions as required.

## 8.5 Push Buttons

The push buttons shall be momentary make / break contact type (normally open / normally close) and suitable for flush mounting. The push button for ON and OFF switching shall be red and green respectively.

## 8.6 HRC Fuses

HRC Fuses shall be provided complete with fuse bases, fuse, etc. The fuses shall have a fusing factor as specified for class QI in accordance with BS 88.

## 8.7 Pilot Lamps

Switchboard shall be provided with phase indicating pilot lamps. The lamps shall be rated for 250 volts supply and suitable for flush mounting. The front of the lamps shall have colored rosettes for identification of phases.

## 8.8 Line up Terminals

Line up terminals wherever provided for Control or Power circuits shall be suitable for voltage and size of conductors as indicated on drawings. The Line up terminals for controls shall be suitable for

channel mounting. All necessary accessories such as end-plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

### 8.9 Secondary Wiring

All wiring shall be copper conductor, thermoplastic insulated, at least 1.5 sq. mm flexible, neatly arranged and clipped in groups.

Each conductor and its termination are to be identified and marked with numbered ferrules. All live terminals are to be shrouded.

Secondary wiring for Current Transformers shall be carried out with not less than 2.5 sq. mm. Terminals shall be specially marked to avoid opening of the circuit by accident.

## 9. INSTALLATION

The LV Switchboard shall be installed at location shown on the drawing. The Contractor shall ensure coordination with civil works for providing any openings, holes, etc. to avoid any breakage to completed works. In case the provisions in civil works for the installation of electrical equipment are not made or made incorrect the same shall be rectified by the Contractor at his own cost and to the satisfaction of the Engineer. The Contractor shall provide foundation bolts and grout them in cement concrete floor using non-shrinkable material with the approval of Engineer.

All installation material for physically erecting the Switchboard, such as bolts, nuts, washers, supporting steel, etc., shall be provided and installed by the Contractor. The Switchboard shall be installed upright and in level and shall be firmly and rigidly bolted to the floor and concrete supports.

The switchboard shall be completely erected as per manufacturer's instructions and as approved by the Engineer. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing provided by the manufacturer. Any safety locking provided by the manufacturer for safe transportation shall be released only after the switchboard is erected in position.

The incoming and outgoing cables shall be connected as recommended by cable manufacturer. The cable armour shall be connected effectively to ground.

The Switchboard body shall be connected to earth as per instructions given in section "Earthing" of these specifications. The Switchboard shall be tested and commissioned in the presence of the Engineer. The tests to be carried out shall be tested before energizing as per instructions contained in the article " Testing " of General Specifications of Electrical Works, section E-1 of these specifications.

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# LOW VOLTAGE CABLES AND WIRES

# LOW VOLTAGE CABLES AND WIRES

## 1. SCOPE OF WORK

The work under this scope consists of supplying, installation, testing, connecting and commissioning of all material and services of low voltage cables and wires and the accessories as specified herein or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with others for exact route, location and positions of electrical lines and equipment.

The LV cables and wires with accessories shall also comply with the General Specifications for Electrical Works, Section E- I and with other relevant provisions of the Tender document.

## 2. GENERAL

All multicore and single core wires for light circuits, socket outlets and circuits operating upto 250 volts shall be 300 / 500 volts grade. All single core sheathed cables shall be of 450 / 750 volt grade. Power cables for main feeders, main to submain feeders, power equipment, etc., armoured or unarmoured shall be of 600 / 1000 volts grade. Armouring of cables shall be done with appropriate size galvanized steel wire as per codes.

The conductors shall be stranded or solid, high conductivity, soft annealed copper. Conductor of single core cables shall be circular, whereas of multicore cables may be circular or shaped according to standard practices and codes. The PVC insulation shall be extruded with a PVC compound having good flexibility, resistance to aging and ability to withstand the ambient temperatures as given in General Specifications for Electrical Works, Section E-1 of these specifications. Cable should be capable of running 125% of full load current without any damage.

## 3. STANDARDS

LV Cables and Wires shall comply with Section – E -1, Clause 3.

Particular reference shall be made to:

- BS 6004 / 6346 — PVC insulated cables for lighting and power.
- BS 6746 — PVC insulation for electrical cables.
- BS 6360 — Copper conductors
- BS 6500 — Insulated flexible cords.

Any other standard referred to in above standards or these specifications.

## 4. MATERIAL

### 4.1 General

The power, lighting and control cables shall be furnished and installed in accordance with the routes and requirements shown on the drawings.

All cables shall have phase identification colours on insulation of each core. The colour code for three phase circuits shall be red, yellow and blue for phase conductors and black for neutral conductor. Where insulated earth conductor is installed, it shall have green colour insulation.

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Single phase circuits shall have insulation of red colour for phase / line, black colour for neutral and green colour for earth conductor.

All DC circuits shall have insulation of red colour for positive, black colour for negative and green for earth conductor.

The ends of each length of multicore armoured or unarmoured cables shall be properly marked for clock-wise and anti clock-wise sequence of core colours.

### 4.2 Cables for Conduit Wiring

All cables / wiring in concealed or surface mounted PVC or steel conduits shall be single core PVC insulated of specified grade and size, unless specifically shown on the drawings or given in BOQ.

### 4.3 Cables on Surface / Concrete Trenches

Cables for distribution system to be installed on surface, in cable ducts, in concrete trenches or on trays shall be single or multicore PVC insulated and PVC sheathed of specified voltage grade and size, unless specifically shown on the drawings or given in BOQ.

### 4.4 Underground Installation

Cables for laying directly underground shall be PVC insulated, PVC sheathed and armoured with galvanized steel wire. Cables fully installed in underground ducts / pipes and mechanically protected from end to end shall be PVC insulated and PVC sheathed unless specifically shown on the drawings or given in BOQ.

### 4.5 Cable Accessories

All cable accessories shall be provided for the complete cabling and wiring system without any additional cost unless specifically mentioned in BOQ. These shall include but not limited to the items such as saddles, clamps, fixing channels, connectors, cable joints (where necessary and approved by the Engineer), clips, lugs, tapes, solder, identification tags, bushes, glands, etc.

## 5. INSTALLATION

### 5.1 General

When the laying is effectuated by others, the contractor shall test the cable characteristics insulation and continuity, at all phases of these and communicate them in a report to the Engineer, as per recommendations of the standards according to which the cable is manufactured.

The cables shall be spaced by categories along their entire length as well as upon penetration into buildings and in their interiors, according to their following rated voltages:

- 30 cm at least between a cable carrying I KV - 30KV and other cables.
- 20 cm at least between a cable carrying voltages between 50V - 500V, and any power or control 10 cm at least between a cable carrying voltages lower than 50V and telephone or these possible being grouped.

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All installation material, labor, tools and accessories for cable installation shall be furnished by the Contractor. The cable and accessories shall be installed as described in accordance with these specifications, drawings and manufacturer's instructions.

## 5.2 Conduit Wiring

The wiring through conduit shall be started only after the conduit system is completely installed and all outlet boxes, junction boxes, etc., are fixed in position. The filling rate inside the conduits shall not exceed 50 %. Cables directly embedded in the masonry are not accepted.

The wires shall be pulled in conduit with care, preferably without the use of any lubricant. Where necessary and if approved by the Engineer, the cable manufacturer's recommended lubricant may be used. Where several wires are to be installed in the same conduit, they shall be pulled together along with the earth conductor. All wires of same circuit shall be run in one conduit.

The wires shall not be bent to a radius less than 10 times the overall diameter of the wire, or more if otherwise recommended by the manufacturer.

The wiring shall be continuous between terminations and looping-in system shall be followed throughout. Any joint in wires shall not be allowed. The use of connectors shall only be allowed at locations where looping-in is rendered difficult. The consent of the Engineer shall be required for using connectors. The connector shall be of suitable rating having porcelain body with sunk-in screw terminals. The connector shall be wrapped with PVC insulation tape after its installation. A minimum of 150 mm extra length of cable / wire shall be provided at each termination to facilitate repairs in future.

## 5.3 Cables on Surface / Trenches

All cables for installation on surface of wall, column, ceiling, trenches, etc., shall be fixed to the surface by means of galvanized steel clips, secured to a steel channel using suitable stud plate, nuts and washers.

The erection of cables and position of support shall be agreed by the Engineer on site, having taken into consideration the accessibility of all such routes. These shall be so arranged that cable crossing one another be minimized if cannot be avoided.

Cables shall be fixed throughout their length by means of approved saddles, clips, etc., at every 600 mm vertically and 900 mm horizontally.

Cables and equipment fixed to a building fabric, i.e., brickwork, concrete, etc., shall be fixed by means of appropriate fixing devices, i.e., Raw bolts, Hilti fixing devices, etc., or alternatively by means of suitable fixing devices cast at site, e.g., concrete inserts.

Contractor shall be responsible for all drilling of steel work, brick work and masonry where necessary for fixing clamps and brackets for supports.

Cables shall not be pulled into conduit until the conduit system has been completed, cleared and free from obstruction and sharp edges.

It shall be ensured that conduit system is clear before cable is drawn in, cables shall be put into conduits in such a manner that there will be no cuts or abrasions in the cable insulation, protective braid and jackets. There shall be no link in the conductors.

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Distance of saddles shall be used for installation of cables in defined condition of the surface of wall etc.

Grease or other injurious lubricants shall not be used in pulling cables. The use of talc or non injurious lubricants is permissible, if desirable.

The number of wires installed in any conduit shall be such that the resulting space factor does not exceed 50 %. Spliced wires shall not be pulled through conduits.

All conduit wiring shall be carried out in the loop - in principle from outlet box to outlet box and in no circumstances shall joints be used except in fixed base connection blocks housed in outlet boxes.

The vertical clearance between two adjacent cables at any point is 50 mm minimum. Common mounting, channels are to be furnished for cable along the same route. The Contractor can offer alternate cable fixing arrangement, which shall be approved by the Engineer before commencement of installation.

The wall crossings where the outdoor cables penetrate in the building shall be carefully obstructed by means of polyurethane foam. The Contractor shall be fully responsible for the perfect tightness of these cable penetrations.

## 5.4 Underground Cables

The Contractor shall plan and take special care to prevent any damage to existing under ground facilities such as under ground piping, cables, foundations, etc. The Contractor shall notify the Engineer of any obstruction encountered and shall provide protective support or removal of such obstructions as instructed by the Engineer. Excavation adjacent to existing facilities, such as foundations manholes, ducts, under ground pipelines and paving shall be braced and / or shored properly to protect those facilities during excavation and construction.

Sufficient slack shall be left in cables for this purpose that cut lengths of cables shall allow about 3% more in the measured lengths between terminations.

Cables, whether installed under ground or in concrete trenches, shall not be bent to a radius less than 10 times the diameter of the cable or as recommended by the cable manufacturer, whichever is higher.

All cables shall be marked at least at each end, switch gear and equipment termination, where cable enter or leave under ground cable trenches or channels, where cable rises from one level to another, at 30M intervals with predetermined identification numbers, by means of proprietary non-deteriorating type, PVC, heat shrinkable, strap-on type or equivalent, for the identification of cable and circuit. These shall be indelibly marked with cable number and securely fixed to the cable. Where conductors are left to be terminated by another party or left to be connected later, they shall be identified. The earth continuity conductor shall be laid in the trench with the cables.

Cables entering the buildings shall also be laid in protective pipes. The protective pipe ends, after installation of cables, shall be plugged water tight by means of polyurethane foam / bituminized Hessian or equivalent method as approved by the Engineer.

## 5.5 Cable Termination and Joints

Cables shall be terminated in a safe, neat and approved manner at the associated equipment, included that erected by others.

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Compression type connectors (lugs) shall be of the correct size and approved type for the conductors concerned. Compression tools shall be supplied for specific use and shall be maintained in good order. After compression the conductor and terminal shall form a solid mass ensuring good conducting properties and mechanical strength. The compression jointing system used throughout the installation must be approved by the Owner or his representative before use.

The Contractor shall be responsible for all drilling and if necessary, tapping entries where these have not been provided by others.

When preparing cables prior to fitting glands, the gland manufacturer's instructions for cable preparation shall be observed. In all cases where armoured cables are used, care shall be taken to ensure that the lay of the armour is maintained after the gland is completely fitted.

Termination and joints shall be suitably insulated for the voltage of the circuits in which they are used.

Every compression joint shall be of a type, which has been the subject of a test certificate as described in BS 4579.

Cable ends, which are not terminated immediately after cutting, shall be sealed effectively to prevent ingress of moisture and shall be protected from damage until termination.

For all cables above 6 sq. mm in section, if a substantial mechanical clamp is not provided a compression type lug or socket shall be provided. At all equipment, cable shall be installed and terminated so that no strain is imposed on the cable or gland and due allowance made to counter the effect of vibration. At all termination an ample length of 'tail' shall be left.

Where joints in cable conductors and bare conductors are required, they shall be mechanically and electrically sound and they shall be accessible for inspection. Joints in non-flexible cables shall be made either by soldering or by means of mechanical clamps or compression type socket, which shall securely retain all the wires of the conductors.

Any joint in flexible cable shall be made by means of cable coupler. Cable couplers and connectors shall be mechanically and electrically sound and shrouded in metal, which can be earthed. Where the apparatus to be connected require earthing every cable coupler shall have adequate provision for maintaining earth continuity.

Cables of AC circuits, installed in PVC or steel conduit shall always be so bunched that the cables of all phases and the neutral conductor (if any) are contained in the same circuit. The outdoor apparatus shall normally be connected by means of cables with conduit termination down to about 30 cm below ground level or concrete foundation. The conduit shall be firmly secured down to their penetration into the trench or channel.

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# UNINTERUPTED POWER SUPPLY (UPS) SYSTEM

# UPS SYSTEM

## 1. GENERAL

### 1.01 WORK DESCRIPTION

a. The continuous operation interruptible power supply system, to EN 50091, hereafter referred to as the UPS, shall be designed to supply uninterrupted, clean electrical power to the Employer's microprocessor-based electrical systems.

b. This section specifies the engineering, supply, delivery to site, installation, testing, commissioning and maintenance of Uninterruptible Power Supply (UPS) System as described herein and shown on the Drawings.

c. The UPS system shall consist of rectifier/battery charger, batteries, inverter, static bypass transfer switch, synchronizing devices, protective devices, external mechanical bypass switch, filter circuits, and accessories as specified herein that will automatically maintain the continuity of electrical power within specified tolerances, without interruption, upon failure or deterioration of the normal power supply. Continuity of electric power to the load shall be maintained during the power failure period with the inverter supplied by the batteries, for the duration as specified or until restoration of the normal power supply as required to meet the Civil Defence requirement.

d. The UPS shall supply continuous, _on-line' electrical power within specified tolerances to connected load, even upon failure or deterioration of the normal mains supply, ensuring continuity up to the specified battery autonomy.

e. The UPS system shall be manufactured in a modular way so as to enable the power of the UPS system installed to be easily increased on the site by paralleling more than one module to meet the new operating requirements and the desired reliability. In this connection, transformation of a unitary module into a multi-module configuration shall be able to be carried out directly on site without returning the equipment to the factory for modification and with a minimum installation down time.

f. Single module system shall have the rectifier / charger, inverter, static bypass switch and all the necessary monitoring and control functions contained in a single metallic cabinet. Multi-module system shall have separate cabinet containing the rectifier / charger, inverter and the necessary monitoring and control functions for each module, and with a separate dedicated cabinet to house the system control and monitoring functions and static bypass switch.

g. All equipment except portable equipment shall be firmly held in place. Fastenings and supports shall be adequate to support their loads with a minimum safety factor of three (3) times.

### 1.02 STANDARDS

A. The complete UPS system shall be engineering and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC:

1. BS7671 - Code of Practice for Electrical Installations

2. BS7430 - Code of Practice for Earthing

3. BS5266 - Code of Practice for the Installation and Maintenance of Emergency Lighting and Power Supply Systems in Buildings

4. BS 727 - Specification for Radio-Interference Measuring Apparatus

5. BS 800 - Specification for Radio-Interference Limits

6. BS 4417 - Specification for Semi-conductor Rectifier Equipment

B. The manufacturing of the cable shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer

C. In the adoption of standards and requirements, the Contractor shall take the following precedence:

i. Engineer's decision;

ii. Local codes of practice;

iii. Drawings;

iv. Specification;

v. International standards and requirements.

## 1.03 QUALITY ASSURANCE

A. UPS ratings shall be the final effective values after the application of all appropriate derating factors. These ratings shall be adjusted to suit local conditions, viz. maximum ambient temperature, etc. Derating factor due to the non-linearity of the load to be connected to the UPS shall be taken into account in sizing the UPS.

B. The UPS shall be manufactured for continuous reliable operation such that the ¯Mean-Time-Between-Failures‖ (MTBF) for individual modules of the UPS viz. Rectifier / charger unit, inverter unit and static switch, etc. shall be more than 8760 hours.

C. To ensure minimum down time, the ¯Mean-Time-To-Repair (MTTR) of the UPS shall not exceed one (1) hour. The MTTR shall be the time required to diagnose the fault and restore the UPS to normal working condition, say by means of module replacement at site, but excluding the travelling time.

D. All battery use shall be heavy duty type of life span of minimum 5 years

E. Factory Acceptance Test

The factory acceptance test shall be detailed and performed to insure that all features of the equipment are functioning properly and that the equipment site test will be accomplished without any major problems.

The factory acceptance test shall include the following as a minimum:

i. Full load and half load efficiency test;

ii. Frequency and voltage limits over the whole range of load;

iii. Overload voltage and short circuit protection;

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iv. Voltage and frequency regulation during sudden load application;

v. Overload performance;

vi. Instrument calibration;

vii. Output tests while being supplied for batteries only; and

viii. Battery charging and discharging test.

## 1.04 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As a minimum requirement, the submission shall include the following:

i. Equipment submission with manufacturer‘s data;

ii. Shop Drawings sharing the co-ordinated installation detail and control block diagram;

iii. Builder‘s works requirement;

iv. Battery arrangement and manufacturer confirmation on ¯zero‖ gas emission by battery to meet Civil Defence requirement without separate room ventilation requirement.

C. The following documentation/accessories shall be supplied along with the equipment:

i. Complete circuit diagrams for UPS and stabiliser (3 copies).

ii. Operation and maintenance manual, with parts catalogue (3 copies) for UPS and stabiliser.

iii. Wall-charts, in plastic frames, covering operation, maintenance, and trouble shooting of UPS and stabiliser.

## 2. SYSTEM OPERATION

Modes of Operation

A. The UPS system shall operate in the following modes:

— Normal (mains up)

Under normal conditions, power from the mains shall be supplied to the rectifier/charger unit. The rectifier/charger unit shall convert the incoming AC power to DC power which is fed into the inverter unit and battery unit. The inverter unit shall convert the DC power to AC power, which is then supplied to the load through the static transfer switch. As long as the operable inverter unit is supplied with DC, it shall supply AC to the load.

— Emergency (mains down)

On failure or excessive deterioration of the mains supply, the inverter shall continue to supply the critical load from battery power without interruption or disturbance.

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— Battery recharge (mains restored)

When main power is restored, the rectifier/charger shall again power the inverter without interruption or disturbance to the critical load, while at the same time recharging the battery.

— Automatic bypass (static switch)

The static transfer switch shall normally connect the inverter output power to the load. Should the inverter malfunction, the static switch shall automatically transfer the load to the bypass source without interruption of the power supply to the load.

In the event of overloads exceeding system capabilities (short-circuits, heavy inrush currents, etc.) or inverter shutdown (manual for maintenance or automatic for internal faults), the static bypass transfer switch shall instantaneously transfer the critical load to the bypass source without interruption.

— Manual bypass (maintenance)

The UPS shall include a manually-operated mechanical by pass system for maintenance purposes.

To avoid the danger of working on live parts, this system shall be designed to isolate the inverter and the static switch while maintaining load power via the bypass source.

Transfer to the maintenance bypass shall take place without interruption to the critical load.

Similarly, an isolating device shall be provided to isolate the rectifier/charger from the mains power supply.

— Operation without batteries

For maintenance purposes, it shall be possible to isolate the battery from the rectifier/charger and the inverter by means of a circuit breaker.

In such a case, the UPS shall continue to supply the load as specified herein, except in the event of mains power outage.

B. The UPS system shall generally include its basic and supporting equipment for the monitoring, control and protection of the system, including input and output AC filters, electronic AC line conditioner, AC and DC input and output circuit breakers, converter, inventor, shielded isolation transformer, static by-pass switch and mechanical bypass switch. The battery bank may be in a separate matching battery enclosure(s).

C. In the case of the parallel redundant system, the total system load shall be automatically distributed equally between the two UPS modules under normal conditions. Malfunction in one of the UPS modules shall cause instantaneous isolation of the faulty module from the system and the remaining healthy UPS module shall take over the full critical load without interruption. If both UPS modules fail, the critical load shall be transferred to the bypass source.

## 3. PRODUCTS

MAJOR COMPONENTS

### 3.01 GENERAL

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A. The UPS shall be detailed to permit access to modules and assemblies. The placement of parts, test points and terminals shall be such that they are accessible for circuit checking, adjustment and maintenance without the removal of any adjacent module or assembly.

B. The UPS system shall be provided with sufficient built-in diagnostic aids to facilitate trouble-shooting, maintenance and circuit calibration. Each circuit module of the UPS system shall be accompanied by suitable indicators and test points allowing the current status of each module to be monitored as required. The UPS system shall be equipped with an event recorder so that hard copy of critical data or status can be made available for analysing when necessary.

## 3.02 MECHANICAL DESIGN

— UPS

UPS enclosure shall be designed with a sufficiently strong and rigid framework to enable handling and installation operations to be carried out without risk. Access to UPS sub-assemblies shall be provided via front doors equipped with locking facilities or from above via a removable cover. Rear panels shall also be removable. The enclosure shall be mounted on castors and shall have levelling facilities. Sheet-metal shall be protected against corrosion by a suitable treatment such as zinc electroplating, bichromating, epoxy paint or equivalent.

— Cubicle

The UPS shall be packaged in a single integral cubicle with the battery in a separate cubicle. The UPS/battery shall require minimum floor space.

— Connections and busbars

Entry of line and load side power supply cables as well as any auxiliary cables shall be possible from the bottom, or from the rear. Terminals shall be cleanly labelled for ease of installation. The UPS shall be fitted with an earth connection. Any busbars shall be made of rectangular cross-section electrolytic copper or aluminium. The cable entry for the UPS shall be from the bottom/rear.

— Ventilation

The UPS shall be provided with forced-air cooling. To avoid UPS shutdown in the event of ventilation malfunctions, redundant fans shall be provided on the UPS and fan failure shall be enunciated.

— Safety

The equipment shall meet the requirements of protection index IP20 minimum.

For safety of maintenance personnel, control circuits shall be galvanically isolated from power circuits.

Bare live parts which could present a contact danger during normal operating tasks shall be protected by insulating shields.

All equipment shall be designed and built in accordance with accepted Consultation practice and applicable international standards, in particular IEC 146 & IEC 439.

— Noise level

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The sound level of the UPS at full load shall not exceed 60db(A) at 1 metre.

- Environment

  The UPS shall be capable of operating under the following environmental conditions without degradation of its characteristics:

  ambient temperature: 0° C to + 40° C

  maximum relative humidity: 95%

  maximum elevation: 100 metres.

- Start-up, operation, and maintainability

  UPS design shall provide maximum reliability (MTBF) and minimum MTTR (mean time to repair). For these purpose, the UPS shall be equipped with a self-test system monitoring the operation of the unit and identifying the faulty sub-assembly in the event of a problem. Repairs shall be possible by replacing standardized sub assemblies without adjustments.

  The UPS shall also be equipped with a start-up and operating assistance system allowing the non-technical user to carry out these tasks.

## 3.03 RECTIFIER / CHARGER UNIT

A. The rectifier / charger unit shall be provided with an input moulded case circuit breaker. The circuit breaker shall be of the frame size and trip rating to supply full rated current to the critical load and recharge the drained battery at the same time.

B. The charger shall be float type charger and operate on an input voltage of 230V ± 10% or 400V ± 10% and complete with DC voltmeter, ammeter, AC voltmeter, surge suppressor, float and boost charging selector, battery discharging indicators, charger failure alarm and all necessary protection device.

C. The output of the charger shall be capable to maintain the battery terminal voltage at between 1.40 to 1.45 volts per cell while supplying the necessary loads over a variation of ± 10% of main voltage.

D. A boost charge at between 1.55 and 1.65 volts per cell with all necessary load remain in circuit can be made if required. Failure of any component of the charging circuit will not cause permanent damage to the battery by overcharging.

E. Battery charger shall be all solid state providing a constant DC charging voltage to the inverter and for battery charging.

F. The charging voltage shall rise above the float voltage after every load application and then return the charging voltage to float value.

G. Load regulation and voltage regulation shall be automatic. Overload protection shall be current limiting.

H. Charger shall be of the following construction :

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1. Enclosed in a ventilated galvanized steel housing, bake enamel painted, and provided with hinged front panel and vermin proof guard.

2. Hermetically sealed silicon diode full-wave rectifier.

3. Automatic surge suppressor

I. A dry type power transformer of the isolated winding type shall be used for the rectifier unit. When operating under the full load condition and at the maximum ambient temperature, the temperature of the transformer's hottest spot winding shall not exceed the limit of the transformer insulation class of material.

J. The rectifier/charger unit shall have input current limiting facility whereby the maximum input current shall be limited to 125% of the full input current rating. Preferably, the current limit shall be adjustable from 100% to 125% of the full input current rating.

K. The rectifier / charger unit shall provide features whereby when the alternate current (AC) power is returned to the alternate current (AC) input bus after the UPS has been operating on battery power or has been de-energized, the total initial current requirement at the input terminals will not exceed 20% of rated load current, and the current will gradually increase to 100% of full rating over a 15 second time interval.

L. Charging current shall be voltage regulated current limiting. The charging rate shall be sufficient to restore the battery from discharge to 95% charge within ten (10) times the discharge time at full load. After the battery is recharged, the rectifier / charger shall maintain the battery at full charge until the next emergency operation.

## 3.04 INVERTER UNIT

A. The inverter shall be a solid state device of capable of accepting the output of the rectifier/charger or battery and providing rated output within specified limits.

B. The inverter shall be able to sustain an overload across its output terminals, while supplying any load within its rating. The inverter shall not shut off, but shall continue to operate with a current limit of at least 125% of rated current for at least 10 minutes.

C. Above 125% of full output power, the UPS module output voltage shall be progressively reduced to prevent the total load current exceeding 125% of the rated value. If the short circuit is sustained, the inverter shall shutdown and disconnect automatically from the load bus.

D. The inverter shall contain an oscillator capable of operating and maintaining the output frequency of the inverter as specified. The inverter oscillator shall be capable of frequency-synchronizing and phase locking to the main power source frequency. When operating as a slave to the main power and a failure occurs in the slaving signal, the inverter oscillator shall automatically revert to a free running state and maintain the specified limits.

E. The inverter shall have a fault sensing device to activate the static transfer switch for removal of the inverter output from the load, without affecting it to an extent outside the limits as stated in this Specification.

F. Power semiconductors in the inverter shall be fused with fast acting fuses to prevent cascading failures. Each fuse shall be provided with a blown fuse indicator with an alarm light on the control panel.

G. In the case of parallel redundant system, the inverters shall be totally synchronized to meet the requirements as specified in this Specification.

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## 3.05 BATTERY CIRCUIT BREAKER

A. The UPS system shall be provided with a battery circuit breaker. When open, the battery shall be completely isolated from the rectifier / charger and from the inverter.

B. The UPS system shall automatically be disconnected from the battery by opening the circuit breaker when the discharge limit of volts per cell is reached, or when signalled by other control functions. The circuit breaker may also be manually operated during servicing of the batteries.

## 3.06 STATIC SWITCH

The UPS shall be provided with a static switch enabling instantaneous load transfer from the inverter to the bypass power supply (reverse transfer) and vice-versa (forward transfer) without interruption or disturbance provided that the mains voltage and frequency are within the limits specified above (inverter synchronised to mains bypass).

Transfer shall take place automatically upon external overloads exceeding rated capabilities or internal inverter faults. Manually initiated transfer shall also be possible.

If the bypass power supply is outside the tolerances specified above when the overload occurs, the inverter shall limit current to 150% of its rated value for at least 200 ms.

After this time, the inverter shall stop and the load shall be automatically transferred to the bypass power supply. Manually initiation of this transfer as well as transfer back to the inverter shall also be possible.

## 3.07 SYSTEM BYPASS SWITCHES

A. Maintenance Bypass Switch

The UPS shall be provided with an external mechanical bypass switch to manually bypass the entire UPS system for maintenance and service purposes. Load transfer to and from the bypass source shall be a ¯make-before-break‖ type switching such that disturbances seen by the load during a bypass shall not be greater than that specified in this Specification.

B. Static Bypass Switch

A static bypass switch shall be equipped to provide uninterrupted transfer of the load to the bypass source automatically when a malfunction or overload occurs in the UPS system. The transfer shall be performed on ¯make-before-break‖ basis such that the static bypass switch is closed before the static interrupter and/or the output circuit breaker is tripped open. The static bypass switch shall preferably be paralleled with a circuit breaker which is activated together with the static switch and subsequently taking over from the static switch. If the transfer of load to bypass source is the result of an overload, when the overload is removed the load shall be re-transferred back to the inverter automatically. A selection switch shall be provided for manual transfer as well.

## 3.08 STORAGE BATTERY

1. A storage battery bank shall be furnished for the UPS system with sufficient ampere hour rating to maintain the UPS output at the rated output capacity and for a minimum duration as specified in the system specification. It shall be of heavy-duty industrial type detail for power service. Battery cells shall be rechargeable, maintenance free, completely sealed Nickel Cadmium type with cell containers of high impact plastic to give a leak-proof seal. All terminal pillars, connectors and bolt sets of the battery bank shall be coated with petroleum jelly.

2. The ride through capability of the battery bank shall be calculated under the following conditions:

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1. An ambient temperature of 50°C; and
2. An end discharge voltage of 1.0V for nickel cadmium cell.

3. The Contractor shall submit discharge and charging curves of the battery proposed and calculations to substantiate that the battery bank provided is of adequate ampere hour capacity.

4. Battery shall be supplied with :
   1. Rack protected with electrolyte resistant paint;
   2. Intercell and interior connectors protected with anti-corrosive plastic covers;
   3. Special tools and fittings required to assemble the batteries.

5. Battery selection shall be ¯zero‖ gas emission to allow the battery to located in the location without separate room ventilation to meet Civil Defence requirement.

6. All battery used shall be heavy duty type of minimum life span of 8 years.

## 4. UPS CONTROLLER

### 4.01 GENERAL

A. The UPS system shall be fitted with an integral control and indication panel. In case of a separate system control cabinet being provided, it shall match the construction and appearance of the UPS modules and shall contain bus bar connections for the output and bypass switch. The control and indication panel of the system control cabinet shall include all the necessary instrumentation, alarms and indicators showing the operation of the UPS system.

### 4.02 INSTRUMENTATION

A. The UPS shall be provided with, as a minimum, the meters indicated below. All meters shall have an accuracy of at least ± 2% of full scale:
   1. Input voltage and current with phase selection;
   2. DC battery charge / discharge current;
   3. DC battery voltage;
   4. UPS output voltage and current with phase selection;
   5. Reserve source input voltage and current with phase selection; and
   6. Frequency of UPS output and reserve source.

### 4.03 ALARM AND INDICATIONS

The following separate alarms shall be provided for effective monitoring of the UPS system operation, with audible and visual alarms:

A. Rectifier
   1. Input under-voltage
   2. Over-temperature shutdown

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3. Blown fuse
4. Rectifier failure

B. Battery

1. Breaker open
2. Discharging
3. Battery low voltage

C. Inverter

1. Output under-voltage
2. Output over-voltage
3. Over-temperature shutdown
4. Blown fuse
5. Overload
6. Overload shutdown

D. Static Transfer Switch

1. Transfer to reserve inhibited
2. Re-transfer to inverter inhibited
3. Load on reserve
4. Output earth fault
5. Output breaker open

E. Cabinet

1. Ambient over temperature
2. Fan failure

F. BMS Interfacing

1. Interfacing to BMS System shall be provided according to BMS point scheduled on the drawing.

## 4.04 CONTROL

The following system level control functions shall be provided:

A. UPS / bypass transfer / re-transfer switch;

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B. Emergency shutdown push button with protective cover;

C. Lamp test / reset push buttons;

D. Audio alarm test / reset; and

E. AC output voltage adjustable for ± 5%.

## 4.05 MIMIC BUS

A mimic bus with indicating lights shall be provided on the control and indication panel or the system control cabinet. The mimic shall depict a complete single line diagram of the UPS system. The following circuit breakers shall be indicated:

A. Module AC input circuit breaker;

B. Battery circuit breaker;

C. System output circuit breaker; and

D. System bypass circuit breaker.

## 4.06 EMERGENCY SHUTDOWN

A. Local emergency shutdown provisions shall be provided. Activation of the local emergency shutdown switch shall cause the module input, output and battery circuit breakers to open, completely isolating the UPS system from all sources of power. The critical load shall be automatically transferred to bypass uninterrupted when the emergency shutdown is activated.

## 4.07 UPS REMOTE ALARM PANEL

A. Where indicated on the Drawings, a wall mounted remote monitoring panel shall be provided and shall have the following indications as a minimum requirement:

1. UPS on battery alarm;
2. Low battery alarm;
3. Load on bypass alarm;
4. Summary alarm for all module malfunctions;
5. Audible alarm with reset push button;
6. Lamp test push button; and
7. System healthy indicator.

In addition to the above, voltage free contacts shall be available on the UPS module for connection to the remote monitoring panel.

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## 5. ELECTRICAL CHARACTERISTICS AND PERFORMANCE

### 5.01 PROTECTION

A. The UPS shall have built-in self protection against :

1. Over and under voltage power line surges;
2. Over voltage and voltage surges introduced at the output terminals at paralleled sources;
3. Load switching and circuit breaker operation in the distribution system;
4. Sudden changes in output load exceeding the rating limit;
5. Short-circuits at the output terminals;
6. Power semi-conductors in the UPS shall be fused with fast acting fuses so that the loss of any one power semi-conductor will not cause cascading failures.
7. Thermostats shall be fitted to monitor the temperature of the power semi-conductors, such that when over-temperature is sensed, the UPS system shall automatically be shut down and the critical load transferred to the bypass source via the static bypass switch.

B. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of failures within the UPS. Fast acting current-limiting devices shall be used to protect against failure of solid state devices. Internal failure of the UPS shall cause the UPS to trip off-line and switch to bypass automatically. All failure shall generate visual and audible indications.

C. Information shall be generated say in LCD screen display with logging function, within the UPS to maintenance personnel regarding the reasons for tripping.

### 5.02 AUDIBLE NOISE

A. Noise generated by the UPS system under any normal operating condition shall not exceed the allowable sound pressure level of 75 dBA measured at 1 meters from the nearest surface of the UPS cabinet.

### 5.03 ELECTRICAL CHARACTERISTICS

The UPS shall be designed to receive power from the mains (through the stabilizer) with the following characteristics:

A. Input

Voltage = 400V AC + 10%, -15%, or 230V AC + 10%, -15%,

Wiring = 3 phase, 4 wire + earth or 1Phase 2 wire

Frequency = 50 Hz $\pm$ 5%

Current in rush = 20% to 100% of rated load in 15 seconds

Power Factor = Unity to 0.7 lagging

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B. Output

| | | |
|---|---|---|
| 1. | Output Voltage | 400V 50Hz, 3 phase, 4 wire, ± 5% or manually adjustable 230V 50Hz 1 phase, 2 wire, ± 5% manually adjustable |
| 2. | Nature of load | mainly high frequency fluorescent lightings and computer equipment, with total harmonic current flow in the neutral of the UPS being 25% of the fundamental current in one of the phases. |
| 3. | Steady state output voltage regulation loads | ± 1% for balance load;<br>± 2.5% for 30% unbalanced load |
| 4. | Dynamic output voltage regulation | ±5% for loss of AC input; ±10% for full load application or removal via the static switch with recovery to within 3% of steady state voltage in less than 50ms and to within 1% in less than 100ms. |
| 5. | Phase Displacement | 120 deg. + 1 deg. for balance load,<br>120 deg. + 3 deg. for 30% unbalanced loads |
| 6. | Inverter Harmonic distortion (for single harmonic) | 5% maximum<br>(3% maximum) |

C. RECTIFIER CHARGER

- Inrush currents

  A walk-in (¯Soft-star‖) circuit shall be provided to eliminate starting inrush currents by imposing a power ramp at the rectifier/charger input. The power walk-in shall take place in approximately 10 seconds.

- Current limiting

  For longer battery life, the charging current shall be automatically limited by an electronic device to 115% normal full-load current or to the maximum value as specified by the battery manufacturer.

  In addition, a further device shall limit the power drawn by the rectifier/charger to rated kVA to protect the back-up voltage stabiliser and the supply line.

- DC voltage settings

  The DC voltage shall be set in to the charge/floating value specified by the lead-acid battery manufacturer.

- DC voltage regulation

Rectifier/charger regulation shall ensure DC output voltage fluctuations of less than 1% irrespective of load and mains supply voltage variations (within the limits already specified above in 3).

- Ripple voltage applied to the battery

  For longer battery life, the rectifier/charger shall be equipped with a filter limiting the DC ripple voltage to a value less than 1% of the DC voltage.

- Surge-arrester

  A surge-arrester of 4000 joules capacity shall be fitted at the power input, with a response time of 0.001 micro-seconds

D. Static Transfer Switch – Transfer Characteristics

| | | |
|---|---|---|
| 1. | Transfer time | 100ms (overlapping) |
| 2. | Detection time | 4.2ms maximum |
| 3. | Re-transfer mode | Automatic/Inhibit(selectable) |
| 4. | Re-transfer delay | 2 to 32 seconds in automatic mode (selectable) |

E. INVERTER

The inverter shall be sized so that the UPS can supply rated load at rated p.f, in accordance with the following requirements:

- Output Voltage

- rated voltage = 400/230 volts.
- wiring = 3-phase, 4-wire + earth
- steady state voltage regulation = + 1% for a load between 0 and 100% of full rated value irrespective of normal mains supply and DC voltage levels (within the limits specified above in 4 and 5)
- transient voltage regulation = <+ 5%of rated voltage for a 100% load step change. In all cases, the voltage shall return to within steady state tolerances in less than 20 milliseconds.
- phase to phase balance shall be 3% under all conditions including upto 50% load unbalance.
- phase angle between phases shall remain within + 5% of 120°.
- harmonic distortion: the inverter shall be provided with an output filter to limit single harmonic distortion to 3% and total harmonic distortion to less than 5%, irrespective of load and normal mains supply (within the limits specified above).

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- field-adjustable (0-5%, factory set at 2%) IR voltage-drop compensation feature shall be provided, to cater for long cable runs.

➢ Output frequency

- rated frequency = 50 Hz
- rogation: two operating modes shall be provided:

  i) In normal operation, the output frequency of the inverter shall be synchronised to that of the bypass power supply within the limits of ± 0.5 Hz.

  ii) For mains frequency variations exceeding these limits, the inverter shall switch over to a free-running mode, with regulation providing an output frequency to within ± 0.1% of the rated value.

- Slew rate shall be field adjustable (0.5-3 Hz/sec, factory set at 1 Hz/sec).

➢ Overload capabilities

- The UPS shall be able to supply 125% rated load for at least 10 minutes and 150% rated load for at least 30 seconds.

➢ Non-linear loads

- The UPS shall be capable of supplying switch-mode power supply loads (with 3:1 crest factor non-sinusoidal current) without derating.

➢ SELECTIVITY

- If the bypass power supply is within the tolerances specified above, the static switch shall make use of the mains overload capacity to trip the protective devices on the load side of the inverter. If the bypass supply is outside the specified tolerances, the inverter alone shall trip circuit breakers rated at In/2 or fast-acting fuses rated at In/4, irrespective of the type of short-circuit. (In = normal output current).

F. Efficiency

The UPS efficiency shall be 80% minimum under the following conditions:-

The UPS is operating at rated load.

The battery is fully charged and floating on the system.

The input voltage is within ±10% of 400V AC / 230V AC.

The load power factor is between unity and 0.8 lagging.

Efficiency shall be defined as the output power divided by the input power.

G. Radio Suppression

During the normal operation of the UPS system, no radio interference shall be allowed to exceed limits laid down in BS 800 when measurements are made in accordance with BS 727.

## 6. INTERFACING WITH BUILDING MANAGEMENT SYSTEM (BMS)

A. The BMS, to be provided by others, will monitor and log the conditions of the UPS system. All status wirings to be linked to the BMS shall be brought to a marshalling cubicle from which the information will be picked up by the field equipment of the BMS. All status indications shall be provided in the form of dry contacts and in pairs of N.O. and N.C. contacts and RS 485 serial interface.

B. The marshalling cubicle shall be installed at an approved location in an approved detail inside the UPS Room

## 7. EQUIPMENT EARTHING

A. The UPS system output neutral shall be connected to the star-point of the output transformer and the electrical earth. All cabinet(s) shall be solidly bonded to the electrical earth provided in accordance with BS7430 using adequate section of cable or busbar. The earth connections at the cabinet(s) shall be made to the frame earth terminal provided or alternatively to a substantial part of the basic frame rather than to a bolted-on panel.

## 8. EXECUTION

### 8.01 INSTALLATION

A. The Contractor shall submit for the Consultant's approval shop drawings showing the following:

a) General arrangement of the UPS and stabiliser

b) Installation details of the UPS and stabiliser, proposed mounting arrangements, cable entries, etc.

c) Routing and fixing details of all power and control cables

d) Mounting details (elevations, sections) of equipment and cable entries

B. Installation of the UPS shall be carried out in accordance with the manufacturer's recommendations and the instructions of the Employers/Consultant.

C. The Contractor shall install the UPS and make all cable, earthing, and control connections in accordance with the manufacturer's wiring diagrams and instructions.

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D. All materials required for complete installation, commissioning, and testing, including mounting/foundation arrangements, bolts, shims, etc., shall be provided by the Contractor within his quoted price.

## 8.02 TESTING AND COMMISSIONING

A. The Contractor shall supply all tools, devices and equipment needed to complete the test. Site test requiring a load bank shall be performed only if specially requested by the Employer. The load bank shall be furnished by the Contractor, if required.

B. Start-up and Site Test

On-site inspection and testing of the UPS system after installation shall be provided by the Contractor and included in the Contract. The site acceptance test shall be detailed and performed to ensure that the equipment will perform with the actual load as installed.

C. Site Acceptance Test

The site acceptance test shall include:

1. Functional tests on all equipment to demonstrate the system constructed are fully in compliance with the specification;
2. Simulation tests to simulate all alarms and faults;
3. System bypass, mains failure simulation test; and
4. Noise level test;
5. Full load test to verify the battery capacity.

## 8.03 MAINTENANCE & WARRANTY

The Contractor, as a representative of the manufacturer, shall warranty the equipment and system to be free from all defects for a period of one year from the date of certificate of completion. All defective parts within this period shall be replaced by the Contractor free of charge. Additionally, the batteries shall be covered by a 5-year (from the date of certificate of completion) pro-rata warranty.

The Contractor shall train the Employer's staff in the proper operation and maintenance of the equipment. The Contractor shall set up a maintenance log book to be kept on site, to enable the Employer to record periodic checks, alarms, comments, etc.

## 8.04 SERVICE CONTRACT

The Contractor shall also guarantee prompt after-sales service of a standard quality, which is internationally acceptable.

The Contractor shall submit priced drafts of his standard annual service contracts, including scope of work, etc.

# CONDUITS AND PIPES

# CONDUITS AND PIPES

## 1. SCOPE OF WORK

The work under this scope consists of supplying, installation and commissioning of all material and services of the complete Conduits and Pipes as specified herein and / or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with others for exact route, location and positions of electrical lines and equipment.

The Conduit and Pipes with accessories shall also comply with the General Specifications for Electrical Works, Section E- I and with other relevant provisions of the Tender document.

## 2. GENERAL

The extent of works shown on the drawing does not indicate the exact position of conduit and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer.

The quality and material for the accessories of conduits and pipes such as sockets, elbows, bushings, bends, inspection / pull boxes, round boxes, etc., necessary for the completion shall be similar to that of conduit or pipes. All the accessories shall be supplied by the Contractor without any extra cost and deemed to have been included in the price of conduits / pipes.

## 3. STANDARDS

Pipes and Conduits shall comply with Section - E-1, Clause 3.

Particular reference shall be made to:

| | |
|---|---|
| BS 31 | Steel Conduit and accessories |
| BS 1378 | Galvanized Iron Pipes and accessories. |
| BS 3595 | PVC Pipes and accessories. |
| BS 4607 | PVC Conduits and accessories. |

Any other standard referred to in above standards or these specifications.

## 4. MATERIAL

### 4.1 PVC Conduits, Pipes and Accessories

The PVC conduits and accessories for lighting and power circuits shall be furnished by the Contractor as shown in the drawings or given in BOQ. The PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will be

allowed in special situations only, for which the consent of the Engineer shall be required. The use of sharp 90 degree bends and tees will not be allowed for concealed wiring.

The round PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 64 mm diameter and 64 mm depth. The junction boxes for wall light points shall have minimum dimensions of 57 mm diameter and 40 mm depth. Round junction boxes shall be provided with one piece bakelite cover plate fixed to the box by means of galvanized screws.

The PVC pipe shall be rigid and shall be minimum D-Class (working pressure - 12 Kg / cm), unless otherwise stated on Drawings or Bill of Quantities. Where pipe changes direction, manufactured smooth bends shall be used. For jointing of pipe, all precautions and procedures recommended by manufacturer shall be followed.

## 4.2 Steel Conduit and Accessories

All conduits shall be of heavy gauge 16 SWG steel, manufactured and tested in accordance with latest relevant standards.

The conduit shall be protected by two base coats of red oxide anti-rust paint and finished in first quality black enamel paint. The coating shall be of heavy enamel, which shall not flake or crack during installation and handling. Each conduit length shall be furnished with threaded ends and a threaded coupling at one end. Soft metal bushes shall be provided at conduit termination to prevent damage to cable during pulling operation.

Junction boxes shall be 100 mm square, having minimum depths of 38 mm or 65 mm as required for accommodating the number of wires. The junction box shall be 16 SWG sheet steel provided with anti-rust paint and finished in heavy black enamel paint. The cast Iron outlet boxes for light points shall be round having 50 mm diameter and 63 mm depth. The above dimensions are given as minimum only, and the exact size shall be determined by the Contractor keeping in view the ease of Installation and maintenance. All outlet boxes and junction boxes shall be provided with one piece bakelite cover plate of suitable design.

## 4.3 Galvanized Iron Pipes and Accessories

The G.I. pipes shall be galvanized from inside and outside by hot dip galvanizing method. The pipes shall be free from stains, burrs or any other defect. The accessories for G.I. pipes shall be galvanized from inside and outside. The conduit shall be NPT threaded, with at least 5 complete threads and assembled with TEFLON tape.

## 4.4 Inspection Boxes / Pull Boxes

The rectangular inspection boxes or pull boxes shall be of 16 SWG heavy gauge, sheet steel having nipples welded to box at entry holes to receive PVC conduit with force fit. The box shall be painted inside and outside with black enamel paint over a base coat of red oxide primer paint. The minimum length of inspection box shall not be less than six times the cable manufacturer's recommended bending radius of the cable. All concealed type pull boxes shall have a white plastic sheet of appropriate size fixed to the box by means of galvanized screws.

## 4.5 Adaptable Boxes

Adaptable boxes shall be made of 16 SWG sheet steel box, painted and finished to the same quality as the light Distribution Board. The boxes shall be 50 mm in depth for conduits up to 25 mm diameter, 63 mm in depth for conduits up to 40 mm diameter and 87 mm in depth for conduits up to

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50 mm in diameter. For conduits more than 50 mm in diameter, the minimum depth shall be two times the diameter.

### 4.6 Conduit / Pipe Accessories

Bushes, plugs, glands, etc., shall be of brass and all male bushes shall be of long thread pattern. Covers for boxes shall be screw fixed and finished as the boxes. Gaskets shall be fitted only when finish is galvanized unless otherwise specified.

### 4.7 Cable Trunking

Where required, wiring shall be run in hot-dipped galvanized (after fabrication) sheet steel cable trunking of the specified gauge complete with all fittings and accessories, manufactured and installed in accordance with BS 4678/NEMA. The trunking shall be constructed with return flanges. Trunking covers shall be secured by anchored turn-buttons and locking bars and minimum length of individual sections shall be 2.44-m. The trunking shall be suspended / supported from the structure at maximum 1.5-m intervals with straps and hangers fabricated from minimum 6-mm dia HDGF bars, or supported by angle-iron brackets.

Conduit drips from the trunking shall also be supported with hangers. Factory made connectors shall be used at joints.

Junctions (tee and 4-way) in multi-compartment trunking shall be double depth to avoid reduction in cabling space. Cable in vertical runs shall be supported by pin racks, prongs or bridging pieces. Fire barriers shall be provided at each floor level. Allowance for expansion shall be incorporated.

Bonding links shall be provided at each joint and secured by screws, nuts an shockproof washers. The bonding links shall make contact with the metal of the trunking of fitting, and continuity shall not depend on contact through the screws, nor on removal on site paint finish from ferrous metal.

## 5. INSTALLATION

### 5.1 PVC Conduits - Concealed

The conduit shall be installed concealed in roof, wall, column, etc.

At all joints and bends, PVC jointing solution as manufactured by Pakistan PVC Limited or approved equivalent must be used to strengthen and to seal the joint.

Manufactured smooth bends shall be used. Bending of conduits by heating or otherwise will be allowed in special situations only, for which the consent of the Engineer shall be required. The use of 90 degree bends and tees will not be allowed.

The conduit shall have a minimum of 38 mm cover of concrete. In the reinforced cement concrete (RCC) work, the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories, after pouring of concrete. The concrete shall be supported on top of bottom reinforcement of slab and shall be firmly secured by tieing to the reinforcing steel in order to avoid being disturbed during pouring of concrete.

All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab of beam.

Where conduits have to be concealed in cement concrete (CC) work after concreting, or in block masonry, chases shall be made with appropriate tools and shall not be made deeper than required.

The conduit shall than be fixed firmly in the recess and covered with cement concrete mixture to have to at least 32 mm cover before plastering. The work of curing in the cement concrete work or block masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from Engineer for the route, to suit the site conditions before starting chasing and cutting.

The termination of conduits at or near the Switchboard / Distribution Board is shown diagrammatically on the drawing. The exact final locations of the termination shall be coordinated with the Switchboard / Distribution Board to be installed. Any extension of conduit near the Switchboard / Distribution Board to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all termination of concrete, soft bushes shall be fixed to prevent sharp edges of conduit ends from cutting or damaging the wires or cables to be pulled through them.

The entire conduit system shall be installed and tested before wiring is carried out. Any obstruction found shall be cleared by use of cutting mandrel or other approved device and the conduit shall be cleaned out before the installation of cable.

Pull boxes / Adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of pull boxes or adaptable boxes. However, these shall meet the following requirements:

- Pull boxes.

  For straight runs the spacing shall not be more than 30 meters.

  For runs with one 90 degree bend, the spacing shall not be more than 15 meters.

- Adaptable boxes.

  For conduits up to 25 mm diameter, the boxes shall be 50 mm in depth.

  For conduits up to 40 mm diameter, the boxes shall be 63 mm in depth.

  For conduits up to 50 mm diameter, the boxes shall be 87 mm in depth.

Wherever the conduit lengths cross the expansion joint either along the column or slab, suitable arrangement shall be provided so that when the conduit lengths in the expansion joint are stressed, the conduit neither develops any cracks nor breaks down.

Bending, off setting and similar operations shall be performed through the help of proper bending tool to give a perfect bend of required angle without Desha ping of conduit to the least.

## 5.2 Steel and G.I Conduit

The minimum size of conduit shall be 20 mm.

The use of solid or inspection elbows, bends or tees will not be permitted and 120 degree bends shall be limited to one between any two drawn-in boxes.

Conduit coupling joint shall not be used where conduit enter spout entry boxes. Conduit running, joints shall not be used where conduit enter conduit boxes or spout entry boxes.

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Equipment that is required to be removed for maintenance shall be provided with conduit unions in all conduits that enter such equipment. The use of conduit nipples shall be avoided as far as practicable.

All conduits shall be cut square and reamed at the end. All conduit ends and the inside of conduits shall be clean and free from burrs.

Where bushed spouts or tapped holes are not provided at conduit termination, the conduit shall be terminated in a flanged socket and a smooth bore brass hexagon bush, with a lead washer fitted between the flanged socket and the equipment or box.

All exposed threads and parts where the galvanizing has become damaged shall be thoroughly cleaned and painted with galvanized paint. the exposed conduit ends shall be capped to protect threads from being damaged before installing cables.

Repair painting shall take place before any making good on site or buildings is carried out. The entire conduit system shall be checked for continuity. Any observation found shall be removed without damaging the installation.

The conduit system shall be installed empty with an 16 SWG steel wire drawn through the conduits for pulling of cables. Joints in underground conduits shall be avoided or reduced to the absolute minimum.

Where adjustable dies are used they shall be so adjusted that threads cut with them shall be the same depths as machine made threads.

The use of manufactured bends shall be avoided and instead smooth bends shall be provided by using approved type of bending tools.

Flexible steel conduits shall be installed at all points locations where flexible connection is required, as directed by the Engineer. The flexible conduits when used, shall be protected by external PVC sheath, resistant to oil damages.

G.I. pipes for under ground installation shall be given bituminous paint coating and wrapped with suitable paper or cloth before installation.

### 5.3 Fixing of Conduits and Fittings

Conduits in process units and on steel work with "U" bolt type fixings.

Conduits in buildings shall be fixed with galvanized distance saddles. Where a number of conduits follow a single route they may be fixed to mild steel brackets.

Conduits shall be supported on both vertical and horizontal runs as follows:

- Conduits size 20 mm and 25 mm maximum spacing of fixing 1000 mm.
- Conduit sizes larger than 25 mm spacing of fixing 1500 mm.

All conduit boxes that support fittings shall be securely fixed. All conduits shall be fixed 150 mm before and after every right angle or off set. All conduit fittings and equipment shall be fixed true and line able.

All conduit bends shall be made with an approved conduit bending machine or hickory. The radius of curvature of the inner edge of any bend shall not be less than the following table:

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| Conduit size | Radius |
|---|---|
| 20 mm (3/4") | Not less than 130 mm. |
| 25 mm( 1" ) | Not less than 150 mm. |
| 32 mm ( 1-1/4") | Not less than 200 mm. |
| 38 mm ( 1-1/2") | Not less than 255 mm. |
| 50 mm (2") | Not less than 305 mm. |
| 70 mm ( 2-1/2") | Not less than 380 mm. |
| 82 mm (3") | Not less than 460 mm. |
| 100 mm (4") | Not less than 610 mm. |

Underground conduit stud-up or kick pipe through concrete envelope shall be extended a minimum of 150 mm above grade and adequately braced to prevent shifting during concrete pouring work. The concrete envelope shall extend at least 76 mm above grade.

Under floor conduit installation shall be at a minimum depth of 120 mm from finished floor level. The G.I. pipes / conduits shall be installed at a minimum depth of 1000 mm measured from the top of size to the finished road level.

### 5.4 Location of Conduits and Fittings

Before conduits are installed, confirmation shall be obtained that the conduit may be installed in that position.

Particular attention shall be given to the location of conduits to prevent the infringement of headroom and access ways.

Conduits shall be located to avoid obstructions, furnaces, hot lines and other places of high temperature.

Conduit shall not be located than 150 mm (6") where it runs parallel to or crosses hot surfaces. Underground conduit runs shall be kept to minimum in both number and length. Conduits shall not be recessed in fair brick work.

Draw boxes shall be so positioned to enable the cables to be drawn in easily. The boxes shall not be located in the comers or other such locations and shall be positioned to avoid tight bends, bending and cable kinks.

Conduits shall not generally be installed having a greater length 12,000 mm (40 feet) between draw-in boxes.

Conduit entries shall wherever possible be located in the bottom of boxes and equipment etc.

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# BUSWAY SYSTEM

# BUSWAY SYSTEM

## 1. GENERAL

### 1.01 SCOPE OF WORK

i) The scope of work shall cover the supply, design, manufacture, testing in the factory, packing, insurance, delivery to site, unloading, installation, testing and commissioning of all components with all the necessary accessories in accordance with this technical specification.

ii) Installation will be by electrical contractor as per manufacturer recommendations.

### 1.02 STANDARDS

The bus bar shall comply with the following standards:

a) IEC 61439 – 6

b) IEC 60331 – Fire Resistance

c) IEC 62271 : 200 : 2003

d) IEC 60529 – 2 : 2001

### 1.03 SHOP DRAWINGS / SUBMITTAL

i) Submit installation & shop drawings and as built drawings. The busbar installer shall be fully responsible for coordination with site conditions and with MEP contractors executing other works at site to ensure the proper installation of the busbar without disruption to existing works. All shop drawings submitted to consultant will bear the signature and company seal of the MEP contractors and switchgear suppliers and be duly coordinated.

ii) Shop drawings shall include components, supports and dimensioned system layouts in plan and section. All congested areas to have detailed blowups and sections.

iii) General arrangement of bus duct runs shall be as shown on the drawings. Shop drawings shall show in detail the exact routing of all duct through the building, relative to the building column lines, structural floor slabs, walls, and switchboard interface details.

iv) Submit test results for voltage drop with shop drawings for each rating of duct.

v) Hanger spacing shall be noted on layout drawings and shall not exceed manufacturer's recommendations.

vi) Indoor feeder and plug-in busbar trunking shall be approved for hanger spacing of up to 2 meters for horizontally mounted run and 4.88 meters for vertically mounted runs. Outdoor feeder busbar trunking shall be approved for spacing of up to 1.5 meters for horizontally or vertically mounted runs.

vii) All vertical runs with Tap-off's to be shown in continuous building / architectural sections to be provided by the engineer and should detail the Tap-off unit arrangement.

viii) Submit complete voltage drop calculation complying with voltage drop schedule.

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## 2. PRODUCT

### 2.01 BUSBAR RISING MAINS

i) Consist of bus bars in extruded aluminum housing with openings for duct plug-in units, and shall be complete with all hangers, cable tap boxes, elbows, flanges, bus extensions, end closures, fire barriers, bus plugs and accessories required for the complete installation and as shown on the drawings.

ii) The bus duct shall be sandwich type construction and designed to operate on a 380 volt, 3 phase, neutral, and earth 5 wire, 50 Hz with neutral size same as phase size and shall be sized as shown on the drawings. The bus duct shall be designed and manufactured to comply with IEC 61439-6, BS 159 & 5486.

iii) Be rated for 45 °C ambient at rated current, with voltage drop at unity power factor as per schedule below. The load shall be assumed to be concentrated at the end.

iv) Be braced to withstanding without damage or distortion the stresses due to short circuit currents of 50kA for 1 second RMS symmetrical and shall be ASTA certified.

v) Be capable of having any length removed without disturbing the adjacent sections.

vi) Have its enclosure designed and, installed to ensure a low impedance ground return path along its entire length. Bus plugs and tap boxes shall be positively earthed to the bus duct enclosure.

vii) The busbar trunking housing shall be constructed of code gauge steel and aluminum to reduce hysteresis and eddy current loses and shall be provided with a suitable protective finish of ANSI 49 grey epoxy paint.

viii) All bus bars shall be fully insulated through its entire length.

ix) Have a manufacturer guarantee for bus bar plating against peeling or flaking due to temperature or moisture.

x) Be true sandwich construction with Class B 130°C insulation materials consisting of two layer of head formed polyester film or epoxy powder coat materials around each bus bar.

xi) Have minimum enclosure protection to IP-54, and fully splash proof.

xii) Provide flanges where duct passes through walls or floors and fire barriers where required by Code. Provide moisture barriers for walls between areas of high temperature or humidity differentials.

xiii) The bus bars shall be tinplated or silver plated at all contact surfaces to assure low surface to surface contact resistance.

xiv) The temperature rise at any point of bus bar shall not exceed 55°C rise above the ambient temperature of 45 °C when operating at full load current.

xv) All busbar fitting and accessories shall be manufactured by the same manufacturer.

xvi) The ampere ratings, approximate footage, fitting, plug-in units etc. are shown on the plan. The electrical contractor shall be responsible for routing the busbar trunking to coordinate with the other trades. Final field measurements shall be made by the contractor prior to release to the busbar trunking for fabrication by the manufacturer.

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xvii) The busbar trunking housing shall be totally enclosed non-ventilated for protection against mechanical damage and dust accumulation. And can endure 1000 hour salt spray testing.

xviii) The temperature rise at any enclosure of the busbar trunking shall not exceed 55 °C rise above ambient temperature when operation at rated load current.

xix) On plug-in busbar trunking there shall be three dead fronts, hinged cover type plug-in openings on each side.

xx) All openings shall be usable simultaneously.

xxi) Busbar trunking shall be installed so that plugs are side mounted to permit practical use of all plug-in openings.

xxii) It shall be possible to inspect the plug-in opening and busbars prior to the installation of the plug-in units.

xxiii) Provide expansion joints wherever they exist in building structure or at horizontal lengths exceeding 20m.

xxiv) Busbars shall be of hard drawn silver-plated high conducting copper of 99.9% purity or Aluminium with silver / tin fused coating. They shall be designed for an operating voltage of 1500 volts and a withstand voltage of 10,000 volts.

## 2.02 TAP-OFF BOXES

i) Be equipped with steel spring reinforced contact jaws. Plugs shall be designed to ground to the casing before connection of the jaws.

ii) Be designed so they cannot be inserted or removed in the closed position.

iii) Be complete with current limiting circuit breakers as indicated in the drawing.

iv) Have isolator interrupting ratings of 50 kA for 1 second RMS symmetrical amperes.

v) Covers which have 'releasable' type interlocks to prevent the cover from being opened when the switch is in the 'ON' position.

vi) Be equipped with internal barriers to prevent accidental contact of fish tape and conductors with live parts on the line side of the protective device.

## 2.03 JOINT

i) The busbar trunking joint shall be of the one-bolt type which utilizes a high strength steel bolt(s) and Belleville washers to maintain proper pressure over a large contact surface area.

## 2.04 BUS TIE DUCT

i) Bus tie duct shall be fabricated as per BS 5486 standard from copper bus-bar of required size.

ii) Low voltage Bus Tie Duct system shall be air-insulated, non segregated construction and to be designed to meet the required voltage, ampere and fault level ratings.

iii) The bus bar shall be braced to provide a dynamic short-circuit strength of 2.5 times the rms fault level of the main LV panel.

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iv) Copper Bus bars are sized in accordance with the specified ratings to operate within IEC temperature rise limits. Joints shall be tin-plated.

v) Provision for the Bus expansion furnished as required by the configuration and length of each system.

vi) Flexible connections shall be provided at the transformer end to absorb the vibrations with heat shrink insulation sleeves along with insulation tape over the bolted section.

vii) Adequate high grade non-hygroscopic bus supports are furnished to suit the electrical and mechanical requirements specified for each installation.

viii) Enclosure up to 4000A rating shall be made of sheet steel with minimum 1.6 mm, while above 4000A (up to 6000A), thickness of sheet need to be confirmed to the Design. The enclosure should be of self-ventilation design.

## 3. EXECUTION

(By others supplier to ensure complete shop drawing coordination support and ensure any materials required as called for in section 3.01 below to be provided in project)

### 3.01 INSTALLATION

i) Support bus duct on vertical runs at each floor level. Adjust supports to ensure the weight of the duct is carried by the supports as per manufacturer's recommendation. Install expansion joints at the spacing recommended by the manufacturer, with a maximum of 20m.

ii) On horizontal runs support the duct from hangers on 1000mm centers or as per manufacturer's recommendation. Provide expansion joints at all locations where the duct crosses a building expansion joint and at the spacing recommended by the manufacturer.

iii) Secure all connections with bolts and cup washers, tightened by a torque wrench and as recommended by the manufacturer.

iv) Install and connect ducts so phase rotation is the same throughout the building.

v) Cover the bus duct with a weatherproof heavy-duty plastic envelope. Do not remove until the building is clean and the bus ready to be meggered and energized.

vi) Ensure that all bus duct terminations mate properly with the associated equipment.

vii) ~~Provide curb around interior floor penetrations.~~

viii) Tighten the joint bolts to the required torque in accordance with manufacturer's recommendations.

ix) Meggar the bus ducts in presence of the engineer and re-torque the joint bolts as recommended by the manufacturer.

x) Fire barriers shall be included as an integral part of each feeder bas bar trunking length and fitting and shall be positioned when it passes through fire insulating ceilings and walls. These fire barriers shall be effective not only within the interior of the bus ducts, but also in the space between the bus duct and the protective sleeves of the ceiling and shall prevent fire, smoke and hot gases.

xi) The bus duct trunking system shall be assembled under license to the manufacturer.

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## 3.02 CERTIFICATION

i) The busbar should pass type testing on full range of each rating which is carried by international well-known lab accredited by IEC i.e. KEMA etc.

The busbar passes seismic tests with actual physical product and being certified complying with the seismic zone 2B.

# WIRING ACCESSORIES

# WIRING ACCESSORIES

## 1. SCOPE OF WORK

The work under this scope consists of supplying, installation and commissioning of all material and services of the complete switches, switch sockets, etc., and miscellaneous items as specified herein and / or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with others for exact route, location and positions of electrical lines and equipment.

The wiring accessories shall also comply with the General Specifications for Electrical Works, Section – E - I and with other relevant provisions of the Tender document.

## 2. GENERAL

The locations of the wiring accessories such as sockets, switches etc. are tentatively shown on the drawings. The Contractor shall ensure exact positions and locations of wiring accessories in coordination with other services drawings, as per site requirements and as directed by the Engineer. The Contractor shall be responsible for proper functioning of wiring accessories after installation and Commissioning.

## 3. STANDARDS

Wiring accessories and miscellaneous items shall comply with Section - E-1, Clause 3.

Particular reference shall be made to:

- BS 67 Ceiling roses.
- BS 1363:1984 13A fused plugs and unswitched socket outlets
- BS 116 Two and three terminal ceiling roses.
- BS 2135 Capacitors for radio interference suppression
- BS 3676 Switch for domestic and similar purposes.
- BS 4934 Safety requirements for electric fans and regulators.
- BS 5060 Performance of circulating fans and their regulators.

Any other standard referred to in above standards or these specifications.

## 4. MATERIAL

### 4.1 Switches

Switches for controlling light and fan points shall be single pole, rated for 10 Amp, 250 VAC. The body of switches shall be made of poly carbonate / urea with white face plate suitable for flush mounting on sheet steel outlet box. The switches shall be gang type having silver tipped contacts and operate with snap action.

For locations where switches and fan speed regulators are installed together, single switches shall be grouped and fixed on 3 mm thick plastic sheet screwed to a sheet steel box of appropriate dimensions. The fixing of plates on outlet boxes shall be means of flat head counter sunk galvanized screws with the head of the screw finish flush with the surface of the plate. Except for switches controlling light points, all single switches for fans, sockets, etc., shall have identification symbols on the operating levers.

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Two way switches shall be used to control lights from two different locations as shown on the drawings.

## 4.2 Switch Socket Outlets

Switch socket units shall be of flat pin type and conform to BS 1363, 13A for fused plugs and socket outlets. 2 and 3 Pin rated for 5 Amps. or 2 Pin rated for 5 Amps. Supply as specified in the bill of quantities.

3 Pin 5 Amps. Sockets shall be moulded type having white plastic face plate, suitable for mounting on a sheet steel box of appropriate dimensions. Switch sockets shall have shrouded live contacts such that the earth pin is engaged to socket earth before making with the live contacts. Where specified, the switch socket unit shall have spring loaded dust tight cover for mechanical protection.

## 4.3 Sheet Steel Boxes

The outlet boxes for installation of switches, fan speed regulators and socket outlets shall be 16 SWG sheet steel having appropriate dimensions. The boxes shall have suitable knockouts or welded nipples for receiving the conduits. An earth terminal shall be provided for connecting at least three earth wires of 4 sq. mm. The outlet boxes shall be given two coats of anti-rust red oxide and one coat of enamel before installation. The boxes shall be suitable for mounting flush with the surface of wall or on the surface of wall as may be required. The boxes shall not be less than 75 mm x 75 mm (3" x 3"). All boxes shall be water tight where installed in the vicinity of liquids.

## 4.4 Ceiling Rose

The ceiling rose shall be suitable for 5 Amps. 250V AC. It shall have white plastic moulded base plate, copper or brass terminals for connecting at least two wires of 2.5 sq. mm size. The ceiling rose shall have a cover with cable inlet hole for multicore PVC insulated and PVC sheathed cable.

## 4.5 Fans

### 4.5.1 Bracket Type

The bracket type fans shall be suitable for mounting on the wall and suitable for operation sami-horzontally. These shall operate satisfactorily on 250 volts, single phase, 50 Hz, A.C. supply with + 10 % tolerance.

The sweep of the fan shall be as given in BOQ/drawings.

The fans shall comply with BS 380 as far as constructional requirements, range of fan speed regulator, starting, radio interference, silent operation and temperature rise are concerned. For testing, BS 848 as amended shall be complied with.

### 4.5.2 Exhaust Fan

The exhaust fans shall be three blade types, mounted on the steel/plastic structure of its own, which will be fixed to the structure by means of suitable grouted foundation bolts. The fan shall be suitable for operation on 250 VAC with + 10 % tolerance.

The sweep of the fan shall be as given in Schedule of Quantities/drawings. Fans shall be direct driven and supplied complete with electric motor, back draft dampers and anti-vermin screen. The bearings shall be ball, roller or sleeve type of permanently lubricated and sealed

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type. Wheels shall be heavily and rigidly constructed and accurately balanced both statically and dynamically and free from objectionable vibration or noises.

The fans shall comply with BS 380 as far as constructional requirements, range of fan speed, speed regulator starting, radio interference silent operation and temperature rise is concerned. For testing BS 848 as amended 1 960 shall be complied with.

# INTERIOR LIGHTING FIXTURES

# INTERIOR LIGHTING FIXTURES

## 1. SCOPE OF WORK

The work under this scope consists of supplying, installation and commissioning of all material and services of the complete light fixtures as specified herein and / or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and positions of light fixtures.

The light fixtures with accessories shall also comply with the General Specifications for Electrical Works, Section - E-1 and with other relevant provisions of the Tender document.

## 2. GENERAL

The description of light fixtures in given Bill of Quantities, and stated on the drawings, and relevant material are described in this section. The determination of quality is based on certified photo-metric data covering the coefficient of utilization, light distribution curves, construction material, shape, finish, operation, etc.

The Contractor shall submit two samples of each and every light fixture specified and obtain approval of the Owner before purchasing. The quality and finishes of local make light fixtures (if mentioned in BOQ) shall be same as that of standard manufacturer. The accessories such as ballast, lamp / starter holders, starters, lamps, ignitors, etc., for all type of light fixtures shall be of Philips make.

All fixtures shall be finished in standard colour schemes as mentioned in the manufacturer's catalogue for respective fixtures, unless specifically stated in the Specifications, Drawings or Bill of Quantities or directed by the Engineer.

## 3. STANDARDS

Lighting fixtures shall comply with Section E-1, Clause 3.

Particular reference shall be made to:

| | | |
|---|---|---|
| - | IEC 81 | Tubular fluorescent lamps. |
| - | IEC 82 | Ballast for tubular fluorescent lamps. |
| - | IEC 155 | Starters for fluorescent lamps. |
| - | IEC 400 | Lamp holders and starters holders for fluorescent lamps. |
| - | IEC 566 | Capacitors for use in TL, HP Mercury and LP sodium vapour. |
| - | IEC 598 | Luminaries. |
| - | BS 3677 | Discharge lamp circuits. |

Any other standard referred to in above standards or these specifications.

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# 4. MATERIAL

## 4.1 Fluorescent Light Fixtures

The fluorescent light fixtures shall have lamps and ballast of proper rating as shown on the drawings. Each lamp shall be provided with independent ballast.

The fluorescent lamps shall be tubular, 1224 / 610 mm long, for 40 / 20 watts respectively as specified. The fluorescent colour shall be warm white characteristics with an average output of 3350 lumens (+5%) for 36 watts and 1350 lumens (+5% ) for 18 watts after I 00 burning hours. The ballast shall be polyester filled type, totally enclosed and suitable to operate up to 250 VAC. The power loss shall not be more than 9 / 6 watts for 40 / 36 watts ballast. A wiring, diagram, wattage, voltage and current figures shall be printed on the body of the ballast.

The lamp holders shall be rotary lock-in type. The starters shall be glow type with radio interference suppressor / by-pass capacitor. The internal wiring of the fluorescent light fixtures shall be done with heat resistant wires at the manufacturer's factory. All light fixtures shall be provided with power factor improvement capacitor to give a minimum power factor of 0.90.

The body of the fluorescent light fixtures shall be minimum 22 SWG sheet steel, derusted, degreased, finished in heat resistant paint, stove enameled. Appropriate size bushed wire entry holes, fixing holes and earth terminals shall be provided. Connectors suitable for connecting 2.5 sq. mm cable connectors shall be provided for supply connections. An earth terminal for connection to 14 SWG copper conductor shall be provided.

The light fixtures shall be furnished with perpex diffusing panels " 040 opal acrylic‖ (minimum sheet thickness 3 mm), polystyrene louvers or metal grid louvers or mirror optic reflectors, etc. as specified on the drawings or in BOQ. The louvers shall be secured firmly and in level. The polystyrene louvers shall be white Egg Crate or as approved. The louvers shall be in one section and not in pieces.

The design of light fixture for recess mounting shall be coordinated with the design of false ceiling prior to commencement of manufacture. Shop drawings shall be submitted for approval of Engineer.

## 4.2 Incandescent Light Fixtures

The incandescent light fixture shall be as stated on drawings and bill of quantities. The light fixture shall be finished in standard colors unless otherwise stated on drawings or directed by Engineer. All incandescent light fixtures shall be of international standard and quality. The type of fixtures with manufacturer catalog reference are given on the fixture schedule and in Bill of Quantities. Equivalent fixture may be acceptable provided that the Contractor submits for review all necessary data indicating photo-metric curves to show that the fixture proposed are of the same type, construction and quality.

The lamps for incandescent light fixtures shall be GLS lamps and shall be supplied and installed according to the wattage as indicated on drawings.

Weather proof bulk head incandescent light fixture shall comprise of cast aluminum body and gasketted clear glass cover secured to the body by means of galvanized nuts / screws to give a weather proof and water tight fit. A wire guard shall be provided for protection of front glass against mechanical injury. The gasket shall be weather resistance type. A G.I. wire guard shall be provided on the glass cover. The lamp holder shall be of bi-pin brass having porcelain outer ring.

The glass shade of light fixtures shall be opal white or clear and free from any air bubbles or voids. The shade may be spherical, cylindrical, flattened bottom or any other shape as specified in the

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drawings or BOQ. The glass shall be opal white or clear as furnished by the manufacturer with the light fixture unless specified.

## 5. INSTALLATION

### 5.1 General

The mounting heights of light fixtures are indicated on the drawings, and position of fixtures according to the mentioned scale.
The Contractor must ensure that the light fixtures are installed uniformly with respect to the dimensions of the area. Any modifications due to site conditions may be made with the approval of Engineer. All fixtures shall be carefully aligned before fixing in position. All fixing accessories such as ceiling rose, flexible cord, lamp holder, suspension rod; pipe or chain with suitable canopy, etc., shall be provided and installed.

The wiring between ceiling rose or terminal box and the fixture shall be carried out with 3 core 0.75 sq. mm and I sq. mm copper conductor, PVC / PVC cable respectively for circuits protected by 10 amps. and 15 / 20 amps. MCBs. The wiring inside light fixture body shall be done with heat resistant cables or PVC insulated cable in heat resistant sleeves as approved by the Engineer.

Glasses, shades, reflectors, diffuses, etc., must be in a clear condition after installation.

All light fixtures shall be earthed by an earth wire connected to the earth terminal in the fitting.

### 5.2 Fluorescent Light Fixtures

The fluorescent light fixtures on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface, and in a manner so as to facilitate wiring. Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling. For light fixtures on installation on false ceiling, the installation method detail shall be coordinated with ceiling design and submitted for approval of Engineer. Care shall be taken to prevent the weight of the fixture from being transferred to the false ceiling.
Pendent light fixtures shall have two holes in the top of each casing by a 1/4" diameter galvanized pipe or any other standard method as approved by the Engineer. Wiring from ceiling rose to the fixture shall be installed through the pipe. Proper arrangements such as long threads with check nuts, etc. for minor adjustment in the mounting heights of the fixtures shall also be provided.

### 5.3 Incandescent Light Fixtures

The incandescent light fixture shall be installed on the surface of ceiling or wall by means of nylon plugs and galvanized steel screws, such that their back finish flush with the surface for exposed conduits and flush with outlet box for concealed conduit system. Wherever convenient, screws for fixing light fixtures shall be screwed into the holes of the outlet box. The light on false ceiling shall be installed in a manner as described for fluorescent light fixture.

### 5.4 Outdoor Lighting

For illumination around buildings during dark hours, light fittings in various arrangements shall be provided in accordance with these specifications. The items not shown on drawings or called for, but which are necessary for a complete working system as required, these shall also be provided and deemed to have been considered as such.

In case, the specified materials and equipment are not used, the Contractor shall then essentially use the standard products of a manufacturer, regularly engaged in the manufacturer of the product and shall meet the requirement of the specifications.

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# EMERGENCY LIGHTING SYSTEM

# EMERGENCY LIGHTING SYSTEM

## 1. GENERAL

### 1.01 WORK DESCRIPTION

A. The luminaires schedules indicate the detail requirement of the luminaires selection. The exact luminaires of the installation subject to Engineer approval on the sample. The Contractor shall be responsible to ensure the selected luminaires suit the location of installation. No time and cost adjustment for the Contractor to provide the approved selected luminaires.

B. The Contractor shall co-ordinate the fixing detail of the luminaires, any accessories, brackets, waterproof termination box etc, required to complete the installation shall be included in the Contract

C. Certain types of electrical equipment or systems involving sudden changes, or low frequency or of direct electric current such as fluorescent lamps, contactors, etc. shall be fitted with radio and television interference suppression components suitable to meet the levels specified in BS 800 ―Limits of Radio Interference‖.

### 1.02 STANDARDS

A. The manufacturing of the luminaires shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

B. In the adoption of standards and requirements, the Contractor shall take the following precedence:

i. Engineer‘s decision;

ii. Local codes of practice;

iii. Drawings;

iv. Specification;

v. International standards and requirements.

### 1.03 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As a minimum requirement, the submission shall include the following:

1. Luminaires colour cut sheet submission with manufacturer‘s data, lamp date, IP rating, location of installation, quantity.

2. Sample submission;

3. Lit-up sample submission as required by Engineer.

4. Lit-up sample for all lamps with indication of location of installation and manufacturer recommended lamp life span.

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5. Illumination computer print out for area as required by Engineer.

6. Shop Drawings of the fixing details showing the coordinated installation details.

7. Test reports for all emergency use luminaires.

8. Builder's works requirement.

## 2. PRODUCT

### 2.01 EMERGENCY LIGHT FITTINGS

A. Emergency fluorescent light fitting shall comply with BS5266 and IEC598-2 and shall be individually equipped with battery pack to provide illumination upon sensing of power failure. The emergency fluorescent fittings are required to be type tested by approved testing laboratory to meet BS5266 and IEC598-2.

B. Lights shall be of the self-contained 3-hour maintained/non-maintained type, as specified, with 8 watt high efficiency fluorescent lamp and prismatic diffuser, with maintenance-free NiCad batteries, separate base plate, plug-in luminaries with locking screw. The emergency output shall typically be 180 lumens.

C. Individual control unit and battery pack shall be integrated within the light fittings

D. Batteries shall be sealed nickel-cadmium re-chargeable type to IEC 285 and shall be capable of continuous operation at cell wall temperature of 70°C

E. The batteries shall be capable to maintain the fluorescent lamp for up to two (2) hours after the main supply fails. The lumen output of the light fittings shall not be less than 50% of those under main supply condition throughout the two (2) hours of discharge period.

F. All NiCad batteries shall be of the high-temperature type, with a rated life of at least 5 years. The emergency lights shall be warranted for 3 years from date of commissioning.

G. The charger shall be fully automatic, solid state constant voltage type, with electronic circuitry to protect the batteries against over-charge and over-discharge. The charging system shall be capable of re-charging the battery to full capacity in not more than sixteen (16) hours after a total discharge of the battery.

H. The control circuits shall be suitable for 230 volt ± 10% mains operation and shall be manufactured to enable the luminaries to operate exactly like normal conventional light fittings. An unswitched live wire shall be connected to each and every luminaries with emergency pack so that the luminaries can be switched off either from the associated lighting switches, timers, contactor, etc. However, irrespective of the status of the light switch or the controlling contactor, the light fitting shall automatically illuminate or remain illuminated upon mains failure. Upon restoration of the mains supply, the lamp shall be switched back to mains supply operation and the batteries shall be re-charged again automatically.

I. A circuit switch shall be incorporated in the control circuit to enable testing of the circuit to be carried out. A red neon light shall be provided to show ‗mains supply healthy'.

J. A fused terminal block fitted with cartridge fuses of appropriate rating shall be provided separately for both the charge and the maintained circuit.

K. All Emergency use luminaries supplied by battery or UPS shall be comply with Civil Defence code. All time and cost required to obtain subject test certificate to Civil Defence code shall be included in the Contract.

## 2.02 EXIT SIGN

A. Exit sign shall be surface or recess mount to suit the Architectural detail.

B. The exit sign shall be complete with battery pack of specification refer to Emergency Light Fittings under this Section.

C. The exit sign shall be constructed from mild steel zinc anneal sheet not less than 1mm thickness. All corners and joints exposed to normal view shall be welded, ground smooth and filled where necessary before painting).

D. Exit sign and other legends, which shall be chosen and approved by the Engineer, shall be to BS formats, 180mm or 90mm high, as required.

E. All fittings shall be adequately ventilated to maintain the tube wall operating temperature below 65°C (50°C ambient).

F. The metal shall be spray painted with high grade polyester powder coat on both sides and stored. Total thickness of paint build up shall be not less than 50 micron. Finished colour shall be applied on all surfaces.

G. The Exit Sign shall manufacturer with details to Civil Defence requirement.

H. The fluorescent lamps and control gears shall comply with specification in this specification.

# EXTERIOR LIGHTING FIXTURES

# EXTERIOR LIGHTING FIXTURES

## 1. SCOPE OF WORK

The work under this scope consists of supplying, installation and commissioning of all material and services of the complete light fixtures as specified herein and / or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and positions of light fixtures.

The light fixtures with accessories shall also comply with the General Specifications for Electrical Works, Section 1 and with other relevant provisions of the Tender document.

## 2. GENERAL

The description of light fixtures in given Bill of Quantities, and stated on the drawings, and relevant material are described in this section. The determination of quality is based on certified photometric data covering the coefficient of utilization, light distribution curves, construction material, shape, finish, operation, etc.

The Contractor shall submit two samples of each and every light fixture specified and obtain approval of the Owner before purchasing. The quality and finishes of local make light fixtures (if mentioned in BOQ) shall be same as that of standard manufacturer. The accessories such as ballast, lamp / starter holders, starters, lamps, ignitors, etc., for all type of light fixtures shall be of Philips make or approved equivalent.

All fixtures shall be finished in standard color schemes as mentioned in the manufacturer's catalogue for respective fixtures, unless specifically stated in the Specifications, Drawings or Bill of Quantities or directed by the Engineer.

## 3. STANDARDS

Lighting fixtures shall comply with Section 1 Clause 3

Particular reference shall be made to:

| | | |
|---|---|---|
| - | IEC 566 | Capacitors for use in TL, HP Mercury and LP sodium vapor. |
| - | IEC 598 | Luminaires. |
| - | BS 3677 | Discharge lamp circuits. |

Any other standard referred to in above standards or these specifications.

## 4. MATERIAL

### 4.1 Street Light Fixtures

The street light fixtures shall be according to the BOQ. The fixture shall consist of weather proof, IP-66 rated light weight pressure die-cast aluminum housing, grey stove enameled outside and colored by a molded acrylic cover.

The fitting shall contain a tray carrying all electrical gear. This tray is made of white stove enameled aluminum sheet. The fixture shall have porcelain lamp holder and capacitor.

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The ballast shall be polyester resin filled, totally enclosed and shall have leak proof body. The voltage of the lamp and ballast, and a wiring diagram and other relevant data shall be printed on the body of ballast.

The ballast shall be provided with insulated wires. The voltage of the lamp and type of fixture shall be as specified in Bill of Quantities. Light pole of required sizes as mentioned in the BOQ shall be in and out galvanized with all accessories like base plate, nut, anchor bolts, washer (all accessories shall be galvanized) with grey paint over two coats shall be installed as per BOQ.

The Luminaries shall be dust and jet proof, corrosion resistant and resistant to exhaust gases and cleaning detergents.

The single lamp Luminaries shall be designed to house high-pressure sodium lamps. The complete assembly shall provide the required light distribution pattern.

The Luminaries shall be made of pressure aluminum and silicon alloy. The exterior shall be totally smooth. The copper content shall be less 0.05% to prevent inter-crystalline corrosion.

The mirror reflects shall be of either the high-grade anodized aluminum (99.9%) type, or a white lacquered reflector type, rigidly fixed to the body and easily replaceable.

The control gear shall be within the fixture. The lamp and control gear shall be mounted in two different and isolated compartments.

Each luminaries optical compartment or unit shall be protected by a high impact resistant clear glass protector and shall be dust-and watertight to the recommendation of IEC publication No. 144 or approved equal. The protector shall be smooth to reduce to a minimum dirt accumulation and have and maintain a coefficient of transmission of the order of 88% or better.

The front glass shall be provided with corrosion resistant hinges and quick closing devices for easy access for lamp replacement.

The lamp socket shall be made of high-grade porcelain and be provided with a locking system to prevent loosening of the lamp.

The Luminaries shall also be suitable for ceiling mounting under the bridge by means of suitable brackets and clamps.

The materials chosen shall be able to withstand without damage or ageing alteration in their structural or physical properties the server local environmental conditions in addition to the heat emitted by the lamp.

A suitable terminal block shall be provided to allow connection of the internal wiring and supply cables. Provision shall be made to facilitate maintenance, and easy disconnection and quick replacement of individual components.

The exposed metallic parts of the luminaries shall be factory finished, store enameled with a suitable corrosion resistant paint capable of resisting the heat emitted by the lamp during continuous operation.

The high pressures sodium lamp shall be designed to achieve a long life. The lamps shall have a clear finish and shall have a bayonet-mounting base.

A complement of new lamps of the correct wattage, shapes and rating shall be provided with the luminaries.

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## 5. MEASUREMENT AND PAYMENT

### 5.1 Measurement

The quantities of pay items of light fitting, which constitute the complete and accepted items shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

### 5.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labor, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for false work and other incidental expenses. No separate payment shall be made for work involved within the scope of this section unless specifically stated in the Bill of Quantities or herein.

# LIGHTING POLES & ACCESSORIES

# LIGHTING POLES & ACCESSORIES

## 1. GENERAL

This section together with its appending document covers the minimum requirement for the design, construction and performance of factory built assemblies of lighting pole.

## 2. SCOPE OF WORK

The work under this scope consists of manufacturing / supplying, installation, testing of all material and services of the complete lighting pole as specified herein and / or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with others for exact route, location and positions of electrical lines and equipment.

The lighting pole with accessories shall also comply with the General Specifications for Electrical Works, Section 1 and with other relevant provisions of the Tender document.

## 3. CONSTRUCTION REQUIREMENT

Lighting poles sizes and dimensions shall be as mentioned in the BOQ and as per the drawing. The poles shall be round conical in shape cross section continuously tapered and longitudinally welded. The welding shall be complying with BS 5135; no circumferential weld shall be accepted. The pole shaft shall be fabricated from high strength structural steel, hot dipped galvanized as per BS 729 / ISO 1416 / 91121. The steel used for fabrication shall be minimum yield strength of 3600 kg per sq cm.

Epoxy paint ultra built liner should be applying over the proper galvanizing for extra protection.

The manufacturer shall provide written guarantee that the galvanizing treatment shall be adequate for 15 years of service.

Scratches, marks, dents or other damages to poles and fittings will be the cause of rejection. Any marks or stains resulting from wrapping materials shall be removed.

## 4. IDENTIFICATION OF POLE

For each piece of pole, identification label shall be fitted in front side. The label should mention the height of pole, year of manufacturing and company name. The label shall have block letter 7mm high, black on white background of trifoliate and fixed with screws.

## 5. CABLE CONNECTION BOX

- Electrical Class: Class-II
- Protection: IP- 44
- Cable connection box with 4 Amps fuse for controlling of lighting fixtures.
- Fitted with line-neutral circuit including 4 Amp 10x38 Gg curve fuse.
- The box shall be suitable up to 4 core 35 sq mm cable.

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# 6. MEASUREMENT AND PAYMENT

## 6.1 Measurement

The quantities of pay items of Electrical works, which constitute the complete and accepted items shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

## 6.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labor, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for false work and other incidental expenses. No separate payment shall be made for work involved within the scope of this section unless specifically stated in the Bill of Quantities or herein.

# EARTHING SYSTEM

# EARTHING SYSTEM

## PART 1 – GENERAL

### 1.04 WORK DESCRIPTION

A. This section specifies the engineering, supply, installation, testing, commissioning and setting to work of the complete earthing network for individual earthing systems, circuit protective conductors and bonding conductors. A complete earthing network comprising cables, copper tapes, electrodes and earth bondings of all relevant necessary non-current carrying metal shall be supplied, erected and connected as required.

B. The system shall be a common earthing system as described in the Specification and as shown on the Drawings. Individual earthing systems shall be provided as follows prior to any according to drawing. Earth main MV/LV/Generator Electrical Earthing shall have 2 connection to the earthing system:

1. MV Electrical Earthing
2. LV Electrical Earthing;
3. Generator Earthing;
4. ELV Earthing;
5. Data Earthing;
6. Local Authority's Earthing;

C. Sufficient numbers of electrodes interconnect by stainless tape to form earthing mat so that the overall earth resistance shall be less than 1 ohm for each individual earthing mat.

D. The number of earth electrodes of the earthing mat is indicated on the drawings as minimum. The Contractor shall test the resistivity of soil at site. Exact number of earth electrodes shall be determined by the Contractor to achieve the earth resistance value subject to Engineer approval. The complete earthing installation include earthplate, earth mat detail to achieve the earth resistance value shall be included in the Contract.

E. The Contractor shall inform the Engineer or his representative before driving stainless steel earthing rods into the ground so that he may supervise the operation. Driving shall be carried out only in the presence of the Engineer or the representative and all rods shall be submitted for the examination before use.

### 1.02 STANDARDS

A. Complete earthing system shall be engineering and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC:

1. BS7671 : Electrical Installation
2. BS7430 : Earthing
3. BS6651 : Lightning Protection System
4. BS 7430 : Earthing.
5. IEC 61024-1-2 : Lightning Protection System

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B. The detail of the Earthing System shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

C. In the adoption of standards and requirements, the Contractor shall take the following precedence:

1. Engineer's decision;
2. Local codes of practice;
3. Drawings;
4. Specification
5. International standards and requirements.

## 1.03 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As minimum requirement, the submission shall include the following:

1. Equipment Schedule, including all manufacturer's data;
2. Shop Drawings and Sample Submission;
3. Builder's work requirements;
4. Testing procedures and report format for testing of the earth electrodes and/or earth strips;
5. Soil resisting test report with calculation report for the details of the earthing system detail including quantity and layout of earth electrodes and/or earth strips to achieve the required earth resistance. The report shall be endorsed by the Contractor's Installation Engineer who supervise and endorse the installation upon completion;
6. Proposed details of earthing system including quantity and layout of the earth electrodes and/or earth strips according to the calculation result.

# PART 2 – PRODUCT

## 2.01 General

A. Common earth mats of resistivity of less than one (1) ohm shall be constructed below the lowest floor structure prior to any ground work construction. The stainless steel earth mats shall comprise the complete earth electrodes, earth strips/grids, earth inspection chambers, earth leads, main earth terminals, earth test link boxes at ground level, etc. Under these circumstances, each individual earthing system shall have earth leads connecting its main earth terminal directly to an earth electrode underground as specified.

B. In the case where drilling is required to take the earth rods or stainless steel tapes below ground level, a specified earth resistance enhancement compound shall be added into the bored holes and a mixture at 60% bentonite and 40% of gypsum to 125% of water mixed to give a thick slurry. It shall be grouted into the holes prior to inserting of rods or tapes, and be allowed to solidify. The

hiring of machine drilling equipment and the grouting as described above shall be provided by the Contractor.

C. The earthing system shall be formed as shown on relevant drawings.

D. All stainless copper tape clips, holdfasts, clamps, earth rod clamps, etc. shall be supplied by the same manufacturer of the stainless steel tapes and rods.

E. All earthing products/accessories shall be of Local Authority's approved type.

F. The mating surface of all tapes at joints etc shall be cleaned before clamping and all joints shall be rivetted, joint with proper connector or exothermic welded. All connectors to electrical apparatus shall be made by a bolted connection in a visible and accessible position

G. Copper tapes shall be secured with appropriate size stainless saddles at intervals not exceeding 600 mm and the tapes shall be supplied in long unbroken lengths to avoid unnecessary jointing.

## 2.02 EARTH ELECTRODE

Various types of earth electrodes shall be utilized as specified:

a) 3m length 19-29 mm dia copper rod 99% purity.

b) Tinned copper plate, 600mm×600mm×3.2mm, 99% purity buried at least 300mm below permanent water level at 8.0mm below ground level, which ever is less. A mixture of charcoal and salt (3:1) shall be used as packing 300mm around the earth plate.

c) Chemically activated grounding electrodes, commercially known as CEE (Chemically Enhanced Earthing).

1). Earth Electrode Rods

A. Earth electrode rods shall be 19-20 mm diameter extensible copper clad stainless steel type with internal screw and socket joints, driving head and connection clamp.

B. Stainless steel rods shall have tensile strength of approximately 600 N/$m^2$.

C. Couplings for each section of the rod shall be of same material of the rod, threaded to fit the rod sections. Driving studs shall be used when driving the electrode into the ground. Earth values shall be measured and recorded before coupling and driving in the next section. Additional earth rods shall be driven in if necessary to attain the required effective earth values.

D. Clamping of the earth leads to the earth rod shall be made by earth clamp. The clamps shall be capable of providing a high pressure contact between the earth rod and the earth leads to achieve a low contact resistance.

E. When two or more electrodes are driven to form a group, the heads of the electrodes in the group shall be bonded to each other by means of a 25 mm x 3mm stainless steel tape, laid at a depth of at least 600 mm in soil.

2). Earth Electrode Tinned copper plate

A. Tinned copper plate, 600mmx600mmx3.2mm, 99% purity buried at least 300mm below permanent water level at 8.0mm below ground level, whichever is less. A mixture of charcoal and salt (3:1) shall be used as packing 300mm around the earth plate.

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3). Chemically Enhanced Earthing

A. Chemically Enhanced Earth is an electro-chemical grounding electrode that automatically conditions the soil/rod interface. This is accomplished by absorbing local moisture to facilitate the electrolytic process. The installation must be accomplished in such a manner as to encourage this process.

B. To install the CEE, first bore a hole in the selected location to a diameter of not less than six (6) inches to accommodate the Earth Conductivity Enhancement Compound (ECEC) and a depth equal to the length of the selected rod plus one foot.

C. Remove all of the tapes covering the absorption and electrolyte holes.

D. Insert the electrode in the bored hole to its full length. It is preferable to leave the top exposed and protected by the special wall assembly, as illustrated. Pour 2 to 4 liters of water in the hole as it is being back filled.

E. Tamp the earth in place, leaving space to reach the connections and to install the well access assembly.

F. Make the connection to the ECC copper electrode.

G. Do not install in a place where watershed or downspout carry-off will flood the unit. Provide for carry-off when you install. The unit may be cemented or paved around, providing above instructions is followed and may be installed indoors.

Upon completion of installation of the earthing system, resistance-to-ground (earthing connection) shall be tested with a resistance tester. Where tests indicate resistance-to-ground is over 5 ohms, appropriate action shall be taken to reduce resistance to 5 ohms or less, by installing additional, properly spaced, ground electrode and treating soils in proximity to ground electrode. A retest shall be performed to demonstrate compliance.

All earth electrode penetrations through basement water proofing membranes shall be provided with manufacturer‘s recommended water seal insert sleeve approved by Engineer. The installation of the water seal insert sleeve shall be under the supervision and endorsed by the manufacturer‘s representative to ensure the installation comply with the manufacturer installation detail.

## 2.03 EARTH INSPECTION CHAMBER

A. Earth electrode shall be fitted with a heavy-duty precast concrete inspection chamber/pit complete with heavy-duty cover as specified on drawings.

B. For earth electrodes located outside or on the apron of the building, earth inspection chambers shall extend to a depth of not less than 300 mm below finished ground level and kept free of soil. For earth electrodes located inside building, earth electrodes shall be buried not less than 100 mm below the floor slab structure. Each earth electrode shall be clearly marked ‗SAFETY ELECTRICAL EARTH CONNECTION – DO NOT REMOVE‘.

C. The chamber and cover shall be heavy duty detail to consider the traffic load at the location of installation. The cover shall be recessed cover to receive the Architectural floor finish at the location of installation.

## 2.04 EARTH LEAD

A. Earth leads, also commonly known as earth conductors, shall be used for the final connection between the earth electrodes and the main earth terminals.

## 2.05 EARTH STRIP

A. Earth strips/grids shall be of bare Copper tapes of 25 mm x 3 mm as specified.

B. Earth strips shall be rivetted or joint with proper connector to earth electrodes underground below the floor slab structure, and shall be buried not less than 300 mm below the floor slab structure.

C. In order to minimise the mutual inductance between strips, earth strips shall be positioned at a distance not less than 6m apart unless otherwise specified or as as necessititated by site restrictions

## 2.06 MAIN EARTH TERMINAL

A. Main earth terminals shall be provided for the termination of each earthing system. 50mm x 6 mm tinned HDHC copper earth bars of not less than 1000 mm / as indicated on drawing / BoQ (larger size shall prevail) length shall be installed in the respective plant rooms / switch rooms at a height of 300 mm above finished floor level. The insulators shall be the approved type. Interconnection between plant rooms / switch rooms and connection to earth electrodes shall be minimum 2 direct connection and as per the Drawings and/or as required to complete the installation.

B. Suitable earthing terminals shall be provided in all the equipment housings, switchgear enclosures, relayed and instrument casings and all other electrical metalwork for bonding to earth.

C. The earth connections for all sections of the installation shall be electrically continuous throughout back to the corresponding main earth terminals.

## 2.07 CONNECTIONS

A. Joints in the earth bars, copper tapes and earth mats shall be exothermatically or butt weld or brazed such that the resistance of the section containing the joint shall not exceed that of an equivalent length at unjointed conductor. Any joint so made may be required to be tested to prove compliance with the requirement.

B. The contact faces of all protect coductors shall be cleaned and tinned before connections are made.

C. No drilling of the earth bar shall be permitted except in terminations.

# PART 3 – EARTH BONDING

## 3.01 CIRCUIT PROTECTIVE CONDUCTOR

A. Circuit protective conductor (cpc) is a system of conductors joining together all exposed conductive parts and connecting them to the main earth terminal.

B. The purpose of circuit protective conductor is to provide a path for earth fault circuit so that the protective device will operate to remove dangerous potential differences during a fault condition.

C. The circuit protective conductors shall take the form of separate cable with a sheath in green/yellow colour or copper tape of minimum size 25mm x 3mm.

D. All exposed non-current carrying metal parts of light fittings, switchgears, motors, enclosures, etc. shall be effectively earthed by circuit protective conductors for earth continuity protection.

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E. For equipment where an earth terminal is provided, the earth continuity wire shall be firmly clamped. Where no earth terminal is provided, the exposed metal part shall be cleaned of paint and surface rust before welding the earth continuity lead.

F. The sizing of principal protective conductors shall be in accordance with to the current edition of BS 7671 and BS 7430.

G. The external earth terminal on the outside of the end panel of any switchboard shall be connected to the main earth bar provided in two independent points.

H. Circuit protective conductors shall be provided in electrical and mechanical rooms and along the routes for the bonding of all exposed conductive parts and extraneous conductive parts. A suitably sized earth terminal shall be provided at each zone of the building for this purpose.

I. All exposed conductive parts shall be effectively connected in an approved manner to the principal protective conductors. The circuit protective conductors shall be single core copper cables or high conductivity annealed copper tapes specified. Unless otherwise specified, the minimum cross-sectional area of the circuit protective conductors shall be selected in accordance with BS 7671.

J. Neutral earthing (N.E) shall be done with PVC insulated cables connecting the neutral bar of the LT panel to the substation earth bar.

## 3.02 MAIN EQUIPOTENTIAL BONDING CONDUCTOR

A. This is referred to the conductor for the equipotential earth bondings of the metalwork of other services such as gas and water to the earthing system. This bonding of service pipes shall be made as close as possible to their point of entry to a building.

B. All extraneous conductive parts of the following services shall be connected to the main earth terminal by means of main equipotential bonding conductors:

1. Main water pipes;
2. Main gas pipes;
3. Other service pipes and ducting;
4. Risers of central heating and air conditioning system;
5. Exposed metallic parts of the building structure and as required by the Engineer;
6. Breeching inlets;
7. Fuel inlets.

C. The earthing system shall be bonded to the rebars of the building foundation and UG water tank, with approved rebar clamps/welding of already laid steel reinforcement bars within the structural concrete around the entire periphery of the basement retaining wall to form a continuous loop with clamps to vertical rebar at column positions

D. The metalwork of public gas and water service shall not be used as a sole protective earth electrode.

E. Main equipotential bonding conductors shall have cross-sectional areas not less than half of the cross sectional area of the earth conductor of the installation, subject to a minimum of 6 $mm^2$ for copper cables. A conductor size beyond 25$mm^2$ for copper cables, theoretically, is considered not necessary.

F. Location of all incoming pipes and ductings shown on the Drawings are indicative only and are to be coordinated on site.

## 3.03 SUPPLEMENTARY EQUIPOTENTIAL BONDING CONDUCTOR

A. This is referred to the conductor for the equipotential earth bonding of the metalwork which is not associated with the electrical installation but which may provide a conducting path giving rise to shock.

B. All extraneous conductive parts of the following shall be connected to the earthing system by means of supplementary equipotential bonding conductors:

1. Metal tanks;
2. All metallic cat-walks, platforms, handrails, staircases, ladders within 2m reach of pipes, tanks, cable trays cable ladders, trunking etc which have equipotential bonding.
3. Any metallic cat-walks, platforms, handrails, staircases, ladders etc with attached electrical cabling or fittings;
4. Metallic door frames/doors controlled by electromechanical locking mechanism with an operating voltage or supply voltage exceeding 50V.
5. Metallic support to electrically operated equipment without direct electrical contact with the equipment;
6. Electrically operated roller shutters;
7. Metallic wall cladding containing, or immediately adjacent to, electrical socket outlet or other sources of electricity;
8. Cable ladder, tray and trunking
9. Raised floor system;
10. Electrical facilities in toilets and shower rooms;
11. Exposed metallic parts of building structure, including roof trusses. (If roof trusses connect to lightning conductor earth, no further equipotential bonding is required).

C. The requirement does not apply in the following instances:

Steel reinforced concrete poles in which the steel reinforcement is not accessible;

Exposed conductor parts which owing to their reduced dimensions or their disposition cannot gripped or cannot be contacted by a major surface of the human body, provided that connection of these parts to the protective conductor cannot readily be made or cannot be reliably maintained. This item applies to small isolated metal parts such as bolts, rivets, nameplates and cable clips. A major surface of the human body is considered to be 50mm x 50mm.

Fixing screws for non-metallic accessories provided that there is no appreciable risk of the screws coming into contact with live parts.

Short lengths of metal conduit for mechanical protection of cables having a non-metallic sheath.

D. Local supplementary bonding conductors shall be provided between simultaneously accessible (i.e. within 2m) exposed conductive parts of equipment, between exposed conductive parts and simultaneously accessible extraneous conductive parts, and between simultaneously accessible extraneous conductive parts. The bonding conductors shall be single core copper cables with oversheath in green/yellow colour.

E. Supplementary bonding, conductors shall be sized in accordance with BS7671 which can be summarized as follows:

1. For conductors connecting two exposed conductive parts, the conductor sizes shall not be less than the smaller protective conductor connected to the exposed conductive parts, subject to a minimum of 4 $mm^2$ if the cables are not mechanically protected;

2. For conductors connecting exposed conductive parts to extraneous conductive parts, the conductor sizes shall not be less than half that of the protective conductor connected to the exposed conductor parts, subject to a minimum of 4 $mm^2$ of the cables are not mechanically protected;

3. For conductors connecting two extraneous conductive parts, the conductor sizes shall not be less than 4 $mm^2$, or even 2.5 $mm^2$ if mechanically protected, for copper conductors.

F. All equipment equipotential bondings in area other than plant rooms and within false ceiling shall be concealed. Any remedial work required due to bad connection, open circuit, etc. shall be borne by the Contractor;

G. All earth conductors and earth terminals shall be manufactured to carry the maximum short circuit current at the point of the installation.

### 3.04 CLEAN EARTHING SYSTEM

Clean earthing system must be provided for Telecommunication System, Data Communication etc. as per system's requirements and connected to a separate earth pit. The low current panels shall be connected to separate dedicated clean earthing system.

## PART 4 - EXECUTION

### 4.01 INSTALLATION

i) The whole of the earthing and bonding shall be installed and tested in accordance with the requirements of the IEE Wiring Regulations, LESCO'S requirement and this specification.

ii) Attention is drawn to the use of circuit protective conductors in addition to metallic conduit/trunking.

iii) All enclosures, equipment, exposed conductive parts, extraneous conductive parts, and metallic trunking, metallic conduits, metallic cable trays and other metalwork other than any live part, forming protection to or part of the electrical installation, Including apparatus and appliances, shall be effectively bonded to earth.

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iv) Protective conductors shall be provided in the form of copper tape to all vertical electrical rising bus bars. The size of this tape shall be in accordance with the IEE Wiring Regulations.

v) All bonding and protective conductors, where fixed to bolted connections, shall be terminated on compression type lugs made with an automatic purpose-made machine.

vi) Provide an earth bar 450mm long on 10mm spacers on the wall of each electrical room, and connect to the enclosure and ground buses of all equipment in the room.

vii) Run a No. 120mm$^2$ sheathed copper cables from the main 600V switchboard ground bus to the main water pipe and connect to the upstream side of the water meter.

viii) Bond water main with proprietary purpose made bonding clamps. Scrape and sand the water main to remove all rust, paint or scale at the location where the connection is to be made.

ix) Remove non-conductive coatings from threads or other contact surfaces to ensure good electrical continuity.

x) Provide a separate insulated ground conductor in every conduit, in every system, to all, devices and fixtures.

xi) Protect all exposed earthing conductors from mechanical damage.

Soldered joints are not permitted.

## 4.02 TESTING AND COMMISSIONING

### 4.02.01 GENERAL

i) The complete installation shall be tested and inspected to ensure that it complies with the requirements of this Specification, the IEE Wiring Regulations, and British Standards. The tests shall be carried out in accordance with the IEE Wiring Regulations.

ii) The inspection and tests shall be carried out in the same sequence as set out in the IEE Wiring Regulations and in such time as to allow any remedial work to be completed prior to Practical Completion. Tests shall also include any part of the existing installation related to the new work.

iii) Tests shall be carried out strictly in accordance with a programme to be agreed prior to commencement of such tests. Facilities shall be provided for witnessing of such tests.

iv) All instruments necessary for inspection and testing shall be supplied and shall be properly calibrated and operated by personnel skilled in their use.

v) Allowance shall be made for disconnection or similar operations to satisfy the requirements for testing, etc., and the reinstatement of the installation.

### 4.02.02 CERTIFICATES AND SCHEDULES

i) All values called for under the IEE Wiring Regulations shall be recorded and three copies of the Inspection Certificate described in the IEE Wiring Regulations shall be submitted. The installation shall not be considered as completed unless Inspection Certificates have been submitted.

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# CABLE TRAY, LADDER & TRUNKING

# CABLE TRAY, LADDER & TRUNKING

## 1. RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

## 2. SUBMITTALS

General: Submit the following according to the Division 1 Specification Sections.

Product data for each component. Show tray types, dimensions, and finishes.

Determine the sizes of the cable trays based on the number and size of cables laid on the cable trays plus 20% space for future growth. Cables laid on cable trays shall be spaced twice their overall diameter (consider the largest cable as reference). In case of discrepancy with the contract documents this clause shall prevail, unless approved by the Engineer otherwise.

Shop drawings detailing fabrication and installation of cable tray, including plans, elevations, sections, details of components, and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings.

Co-ordination drawings, including floor plans and sections drawn to accurate scale. Show accurately scaled cable tray layout and relationships between components and adjacent structural and mechanical elements.

## 3. QUALITY ASSURANCE

Manufacturer Qualifications: Select a firm experienced in manufacturing cable trays which has a record of successful in-service performance.

Comply with the relevant standards of BS,NEMA and NEC.

Single-Source Responsibility: All cable tray components shall be the product of a single manufacturer.

## 4. SEQUENCING AND SCHEDULING

Co-ordination: Co-ordinate layout and installation of cable tray with other installations.

Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Engineer.

## 5. CABLE TRAYS

The cable tray system shall be of one manufacturer and shall include factory made trays, tray fittings, connections and necessary accessories and supports to form a complete tray support system.

The cable tray system shall include the following factory made tray elements. Straight trays and ladders, fittings and horizontal and vertical bends of various angle crosses, tees, wyes, reducers, vertical riser elements, connectors and all necessary fixing accessories.

Cable trays shall be constructed from mild steel of minimum thickness 16 gauge (1.5 mm). Trays in excess of 300 mm width shall be of minimum thickness 14 gauge (2.0mm).

Insert elements, bolts, screws, pins etc., shall be mild steel cadmium plated.

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a. Tray work shall have oval perforations. Ladder type trays shall be used as required and/or approved by the Engineer.

b. All trays (straight and fittings) to be heavy duty returned flanged type unless specified otherwise.

c. Tray component are to be accurately rolled or formed to close tolerance and all edges rounded. Flanges are to have full round smooth edges.

d. Ladder racks of widths up to and including 300mm shall be constructed from rolled steel sections of minimum thickness 16 gauge (1.5 mm). Ladders in excess of 300 mm width shall be C Section construction with a minimum thickness of 14 gauge (2.0mm). the rungs shall be spaced at a maximum 300 mm.

e. Unless indicated otherwise on drawings, cable trays shall be used in the range 150 mm to 900 mm wide, in fire preferred standard sizes: 150, 300, 450, 600 and 900 mm.

f. Other sizes shall be used where specified or previously agreed with the Engineer.

g. Flanges shall be a minimum of 50 mm deep.

h. Minimum radius at side rails, horizontal and vertical tees and crosses shall be in accordance with the Manufacturer's standard.

Perforated, heavy duty, return flange type, in 2.5m nominal lengths Hot dip galvanized after completion of bending and drilling, complete with all necessary purpose made bends, tees, supports and the like. Width shall be such as to permit adequate access for installation and maintenance of cables and per the requirements of KESC regulations.

## 6. CABLE TRUNKING

Where required, wiring shall be run in hot-dipped galvanized (after fabrication) sheet steel cable trunking of the specified gauge complete with all fittings and accessories, manufactured and installed in accordance with BS 4678/NEMA. The trunking shall be constructed with return flanges. Trunking covers shall be secured by anchored turn-buttons and locking bars and minimum length of individual sections shall be 2.44-m. The trunking shall be suspended/supported from the structure at maximum 2-m intervals with straps and hangers fabricated from minimum 6-mm dia HDGF bars, or supported by angle-iron brackets.

Conduit drips from the trunking shall also be supported with hangers. Factory made connectors shall be used at joints.

Junctions (tee and 4-way) in multi-compartment trunking shall be double depth to avoid reduction in cabling space. Cable in vertical runs shall be supported by pin racks, prongs or bridging pieces. Fire barriers shall be provided at each floor level. Allowance for expansion shall be incorporated.

Bonding links shall be provided at each joint and secured by screws, nuts an shockproof washers. The bonding links shall make contact with the metal of the trunking of fitting, and continuity shall not depend on contact through the screws, nor on removal on site paint finish from ferrous metal.

## 7. EXAMINATION

Examine surfaces to receive cable tray, cable trunking and cable ladder for compliance with installation tolerances and other required conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

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## 8. WIRING METHODS

Use cable tray of complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold-down devices, grommets, and blind ends.

## 9. INSTALLATION

a. Install cable tray, cable trunking and cable ladder level and plumb according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

b. Remove burrs and sharp edges of cable trays.

c. Make changes in direction and elevation using standard fittings.

d. Make cable tray connections using standard fittings.

e. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.

f. Fire stop penetrations through fire and smoke barriers, including walls, partitions, floors, and ceilings, after cables are installed.

g. Working Space: Install cable trays with sufficient space to permit access for installing cables.

## 10. GROUNDING

Connect cable trays, cable trunking and cable ladder to ground as instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors.

## 11. CLEANING

Upon completion of installation of system, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

# LIGHTNING PROTECTION SYSTEM

# LIGHTNING PROTECTION SYSTEM

## PART 1 – GENERAL

### 1.01 WORK DESCRIPTION

A. The work to be done under this section comprises the engineering, supply and installation necessary for the complete installation of the Lightning Protection System.

B. The Lightning Protection System shall be installed generally in accordance with BS6651 and IEC 61024-1-2 and additional requirements of this specification.

C. The system shall be of the Faraday-cage type and shall consist of air terminations, down conductors, joints and bonds, testing joints, earth terminations and earth electrodes. The general arrangement shall be as indicated on the Drawings.

D. The Early Streamer Emission Lightning Protection System, comprising of ESE Lightning Arrestor shall be provided at top of Tower. The Arrestor shall be mounted on 3‖ dia hot dipped galvanized pipe at least 5 meter from the top of the building. The general arrangement shall be as indicated on the Drawings.

E. The lightning protection system shall comprise:-

1. Early Streamer Emission Arrestor
2. Down Conductors;
3. Joints and Bonds;
4. Test Links
5. Earth Terminations.

F. The down conductors shall be 70 sq mm bare copper conductor which shall be installed in the columns as shown in drawings welded at basement with the Earth Connecting Point. Continuity shall be checked and recorded after each floor pouring.

G. Contractor should also include in his scope inspection by manufacturers authorized representative to ensure correct installation.

H. The Contractor shall submit fully detailed shop drawing for the arrestors, down conductors, earth termination network and bonding and shall be responsible to provide all the necessary accessories to integrate the system with the architectural finish of the building

I. Lightning protection system employing steel structural and reinforcement system as part of the down conductors shall be adopted as per Drawing specified. All requirements in the specification included cast-in re-bar down conductors shall be applied unless otherwise specified.

### 1.02 STANDARDS

A. Complete installation shall be engineering and constructed in accordance with the latest revision of the following standards and the appropriate BS/IEC :

1. BS6651 – Protection of Structures against Lightning

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2. AS1768 - Lightning Protection

3. BS7671 - Electrical Installation

4. IEC 61024-1-2 - Lightning Protection System

B. The detail of the lightning protection system shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

C. In the adoption of standards and requirements, the Contractor shall take the following precedence:

1. Engineer's decision;

2. Local codes of practice;

3. Drawings;

4. Specification;

5. International standards and requirements.

## 1.03 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As a minimum requirement, the submission shall include the following:

1. Equipment submission with manufacturer's data;

2. Sample submission;

3. Shop Drawings showing the co-ordinate routing of air terminations, down conductors bonding to re-bar and foundation earth terminations, methods of fixing etc.

4. Builder's works requirement.

5. Proposal on testing procedures and report format for testing of the Lightning Protection System.

6. Detail of the Contractor's installation Professional Engineer who supervise and endorse the installation for occupation permit application.

# PART 2 - PRODUCT

## 2.01 AIR TERMINATION

A. The Contractor shall supply and install an air termination system consisting of continuous horizontal conductors.

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B. The conductors shall comprise of 25mm x 3mm copper tape unless otherwise specified, located as shown on the Drawings and securely fixed in place to the building structure. Wherever possible, the horizontal conductors shall be continuous lengths.

C. Where saddled to masonry, the fixing screws shall be set in expansion type plugs contained in properly formed holes.

D. All roof conductors are to be secured at intervals not exceeding 900mm.

E. The Drawings showing the various roof levels of the building indicate the general arrangement and layout of the air termination system. The Contractor shall ensure that the whole of the air termination system is installed over its total route of the roof areas maintaining absolute electrical continuity.

F. Provision shall be made with suitable fittings to allow for expansion and contraction of the horizontal conductors.

G. 500mm height vertical copper air terminal shall be provided for the Air Termination network fixing next to masonry material at the highest points and any connection to down conductor.

H. Air termination on the vertical side of the building above 45mm as required by BS6651 shall be provided with maximum 30m spacing and minimum 2 points. The Contractor shall co-ordinate the installation detail to allow for bonding of the curtain wall to the embedded down-conductor re-bar to Engineer satisfaction and comply with BS6651 requirement. All additional materials and installation as required shall be included in the Contract.

## 2.02 DOWN CONDUCTOR

A. The down conductor routes shall be embedded in column as indicate on drawing and shall be as direct as possible.

B. The bonding conductor at roof conductor shall be of soft annealed copper strip minimum size 25mm x 3mm. Where the conductors penetrate the roof, the holes shall be effectively sealed and waterproof with proprietary sealant to the approval of the specialist roofing contractor.

C. All exposed metal running vertically external to the structure shall be bonded to the re-bar down conductor. This shall be included but not limited to curtain wall frame, pipes, ducts and other metal components running through the Buildings.

D. The down conductors shall be run according to the route as shown in the Drawings or as required to BS6651 requirement.

E. The Sub-Conductor shall ensure that the proper material and equipment are used in accordance with the manufacture's recommended installation.

F. Lightning protection system shall employing steel structural or reinforcement as down conductor as per Drawing specified. Additional stainless steel re-bar down conductors shall be embedded in columns or core walls to ensure continuity and run along steel reinforcement with bonding at maximum 1m interval or minimum two (2) points at each in-continuous steel structural member of reinforcement.

## 2.03 JOINTS AND BONDS

A. Stainless steel connection plates shall be provided for termination of exposed copper tape conductors to steel rebar down conductors concealed in structure. All joints and bonds shall be soundly secured and shall be of low resistance. The cross-sectional area of the material used

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e.g. Copper shall not be less than the main conductor (i.e. 25mm x 3mm) unless otherwise specified.

B. Where possible, joints shall be kept as few as possible. All joints shall be carried out with manufacturer's recommended compress type clamp. Two (2) screw minimum shall be provided for each joint.

C. Bonding Points shall be carried out with manufacturer's recommended sets. Customer's self-made items are not acceptable.

D. Joining of dissimilar metals shall be protected from moisture by applying recommended compound on the material. Bi-metal joint shall be provided where dissimilar metals are used.

E. All junction and bonding clamps shall be phosphor bronze material.

## 2.04 TEST LINK

A. A test link shall be provided for testing earthing pit at ground floor. The test link shall be of phosphor bronze and shall be located in an easily accessible position for testing.

B. The test link shall be protected from unauthorized interference. It shall be of an approved type and shall not constitute an electrical resistance within the system.

C. Test clamps shall be provided at air termination network and Earth Termination for each down conductor and so arranged that all parts of the network can be tested independently.

D. After installation and completion of testing, all test clamps shall be painted with bituminous paint to prevent corrosion.

## 2.05 EARTH TERMINATION

A. Down Conductor re-bar will be bonded to foundation steel network Underground stainless steel tapes 25mm x 3mm shall be interconnect all re-bar down conductor at the ground level along the perimeter of the building to comply with IEC 61024-1-2.

B. The maximum permissible earth resistance of the Lightning Protection System shall be 10 ohms. Testing earth electrode shall be provided for earthing test.

C. All earth electrode penetrations through basement waterproofing membranes shall be provided with manufacturer's recommended water seal insert sleeve approved by Engineer. The installation of the water seal insert sleeve shall be under the supervision and endorsed by the manufacturer's representative to ensure the installation comply with the manufacturer installation details

D. The top of each electrode shall be protected from damage by placing it in a heavy duty pre-cast concrete inspection chamber with heavy duty cover. The actual connection of the conductor to the electrode shall be accessible and visible when cover is removed.

# PART 3 – EXECUTION

## 3.01 METALLIC CURTAIN WALL BONDING

A. All elements of the façade shall be directly earthed to the structure for the purpose of lightning protection. The Contractor shall make himself aware of the requirements under the latest revision of BS6651 and IEC 61024-1-2. All necessary connections, conductors, earthing connectors etc shall be deemed to be included in this Contract.

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B. The Contractor shall co-ordinate with the Curtain Wall Supplier/Contractor for the exact interface and bonding requirements. The curtain wall is to be electrically continuous and the installation shall comply with BS6651. Tests shall be carried out by this Contractor to the satisfaction of the Engineer to ensure electrical continuity as stipulated in the code.

C. Lightning protection bonding terminals along each re-bar down conductor shall be provided by the Contractor at the lowest levels and roof levels for bonding with curtain walls. Intermediate bonding terminals shall be provided at an interval of not exceeding 30m apart at each of the vertical intervals of each down conductor.

D. As a general practice, bonding points shall be provided and located on the internal face of the claddings. A conductor shall be provided and installed by the Contractor for lightning protection bonding at the down conductors.

E. The Curtain Wall Supplier/Contractor shall be required to confirm his details on the lightning protection bonding of curtain walls. It is the responsibility of this Contractor to ensure all details (both locations and quantity) agreed complied with BS6651.

F. All metal cladding components including panels, glazing frames, mullions, transoms, fixings and support structures shall be fully bonded electrically to ensure electrical continuity of the building development.

### 3.02 EQUIPMENT/STRUCTURE BONDING ON ROOF & OTHER EXTERNAL AREA

A. The Contractor shall be responsible for bonding of all metal equipment/structure on roof and other exposed external area on flat roof and ground level, complete cabling by means of 25 x 3mm copper tape up to the termination point provided by respective Contractor. Bonding within the equipment for maintaining electrical continuity of all metal components will be provided by the respective work in the Contract.

B. All metallic projections, chimneys, vent pipes, cooling towers, railings, antenna masts, fuel tanks, etc. on or above the main surface of the roof and other external areas shall be bonded to and form the part of the air termination network.

C. For equipment with plan area above 100sq.m, bonding shall be provided at distance not more than 30m apart equally spaced along the perimeter of the equipment.

D. All bonding shall be to the nearest down conductor by most direct route available.

## PART 4 – TESTING & COMMISSIONING

A. The Contractor shall arrange with the Engineer for inspection and testing of lightning conductor system. Before the joint testing, the Contractor shall have conducted his own inspection and testing to ensure that all requirements are met as specified. Test report certified by Contractor's installation Professional Engineer shall be submitted to the Engineer. All equipment, transportation, manpower and other necessary costs for the joint inspection and testing shall be borne by the Contractor.

B. The system shall also be tested at not greater than twelve (12) months intervals for earth resistivity, resistance to earth of the electrodes and electrical continuity of the system during the course of building construction and DLP. The results of these tests shall be by the Contractor's installation Professional Engineer compiled in report prepared by the Contractor.

C. The Contractor shall supply facilities for the recording of the test results referred to above, arranged in such a manner that comparisons can be readily made with earlier readings.

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D. The Contractor shall submit a detailed layout drawing showing the positions of testing carry out on site.

E. The record sheet and layout drawing shall be kept on site at all times during the course of construction.

F. The Contractor shall carry out monthly inspection on the lightning protection system including the earthing pits to ensure that the system is in good working order.

# STRUCTURED CABLING SYSTEM

# DATA / VOICE STRUCTUTRED CABLING SYSTEM

## 1. GENERAL

### 1.01 SCOPE OF WORK

A. The work under this section consists of supplying, installing, testing and commissioning of all material and services for data/voice structured cabling system. The contractor is required to provide and install switcher hubs, patch panels, cabinets, Main Distribution Frames, data/voice conduiting, CAT-6 unshielded twisted pair (UTP), Gigabit Ethernet based data and voice structured cabling, CAT-5E UTP wiring, outlet boxes with RJ-45 sockets and face plates confirming to following ―Standard for Structured Premises Cabling Solutions‖:

- ISO/IEC 11801
- ISO/IEC/TR3 8802-1
- ISO/IEC/8802-3
- ISO/IEC 61935-1
- IEC 60364-1
- IEC 60950
- EN50173
- EN50174-1
- EN50174-2
- ANSI/TIA/EIA-568 – 568A
- ANSI/TIA/EIA - 569
- TIA/EIA TSB-72
- TIA/EIA TSB-75
- BICSI Telecommunication Method Manual
- IEEE 802.3
- Any other local authority having jurisdiction

All works shall be performed in accordance with Rules and Regulations of the Local Authorities. Guideline for the provision of Telecommunication Facilities and to the satisfaction of the Engineer.

Category 6 components shall be able to support frequency upto 250 MHz, speeds upto 100 Mbps, 155 Mbps and gigabit applications.

### 1.02 GENERAL REQUIREMENTS

A. The work shall consist of the following:

1. Provide and install conduit, cable, connectors, wall plates, terminators, pullboxes, patch panels, panel racks/brackets, hubs and other items necessary for a complete working data/voice structured cabling system. All work by the Contractor shall be in accordance with the practices set forth in TIA/EIA 568-A and comply with Local Authority's requirement.

2. Provide electrical services to support the data/voice structured cabling system required under this contract.

B. Provide As-Built drawings identifying the cable path and note any deviations from the original drawings. Also provide all documentation on label and testing information prior to system acceptance.

### 1.03 SUBMITTALS

A. Submit for review by the Engineer a compilation of material specifications to be incorporated in the work. Support submittals by descriptive means, i.e.: catalog sheets, product data sheets, and other literature by the manufacturer.

B. Acceptable materials and manufacturers are listed below and are used only for reference. Materials and products considered as equivalent by the contractor, other than those listed shall be submitted for Engineer approval. Submittals shall consist of substantiation of Local Authority's acceptance, catalog pages with items marked, referenced part numbers for which the substitution is intended, with specification sections and paragraphs referenced. In addition, samples of cables, connectors, and wallplates are required to be submitted for approval prior to installation.

C. Manufacturer's cable markings shall consist of manufacturer's name, cable type/catalog No., 1987 NFPA type code compliance, and the 1993 NEC code compliance.

D. Make submittals for each of the following items as included in the scope of this work:

1. Horizontal cables
2. Backbone Cables
3. Patch cords
4. Connectors
5. Wallplates
6. Conduit, bushings, sleeves, raceway, etc.
7. Patch panels
8. Racks and brackets
9. Hubs

## 2. MATERIALS

### 2.01 SWITCHING HUBS

Switching Hubs shall be of multi-speed (10/100 Mbps) ports, rack sized, having versatile network devices, both standard and ¯Big-Pipe‖ ports. Each Power switch ports shall create a separate network segment and provide dedicated bandwidth to the attached device. All ports shall support Half or Full-Duplex operation. It shall have UTP crossover up link connector. Front Panel LEDs to be provided to clearly display real time network status. It shall comply with IEEE 802.3u 100 BASE-TX standards.

### 2.02 PATCH PANEL

Patch Panel shall be high density Insulation Displacement Contact, having 24 channel version, features channel identification labeling and a Rear Cable Management Tray, maintaining the industry standards approved bend radius required for Category 6 cable plant. It shall ensure that the signal path length is kept within the patch panel to a minimum, consistent and balanced data transmission is assured.

- Cat 6 Unshielded 19‟ Modular Patch Panel
- Including 24 number of 1-GBase-T / modules and Copper conducting tape
- Integrated rear cable management and cable strain relief
- Size 1U
- High grade steel front panel

Screw packs comprising cage nuts, bolts and nylon washers shall be provided with the panels for ease in installation. It shall meet the highest performance standards of AS/NZS 3080, ISO IEC 11801, TIA 568A/B and UL.

Fiber-optic patch panel in the Data centre shall be high-density LC type terminating maximum number of cables in least space. The Data centre patch panel to be equipped with LC connectors, which have permanent cabling, connected at the rear and present forward facing LC

sockets allowing patching with cords fitted with LC connectors. Provision shall be available for storing extra length of fibers and their dressing.

Optical fibre patch panels on the floors shall be equipped with LC-type connectors which have permanent cabling connected at the rear and present forward facing OM3 LC sockets, allowing patching with cords fitted with LC connectors at both ends. Patch panels shall have sliding drawer construction to facilitate easy access to the terminated fibers. Provision shall be available for storing extra length of fibers and their dressing.

All fiber-optic cable shall be terminated with LC connectors. Connectors shall have plastic bodies with ceramic ferrules, with a maximum loss of 0.5dB for each pair of mated connectors.

## 2.03 INFORMATION OUTLETS

Telecommunication modular jacks (RJ 45 type) shall be of the 8-position/8-pin (conductor) type, with T568A (preferred) or T568B wiring configuration, as required by the Employer. Insulation displacement connectors shall accept 23-SWG insulated wire to give a gas-tight connection with an impact tool. The copper alloy socket contact pins shall be plated with 50 micro-inches of gold over 100 micro-inches of nickel-plate, shall have the following characteristics:

- Contact resistance (Max) = 20 m ohms
- Insertion life (min) = 750
- Insulation resistance = 500m ohms
- Current rating (IEC 512-3) = 1.5A

Dedicated colors shall be used for data & voice outlets, which shall be mounted on a flush outlet plate with 87x87 mm (matching the color of other sockets & switches) shutter doors for dust-ingress prevention and inclined at 45 degrees for patch cord strain relief.

Before applying black enamel the cleaned surface of sheet steel box shall be given lead oxide antirust coating inside and outside the box. The cover of such outlet box shall be approved masonite, Teflon, Bakelite or plastic as specified in the Bill of Quantities, for mounting the socket units. Where RJ-45 socket outlet boxes are to be installed on surface in an exposed conduit wiring system, these shall have, in addition to the protective coating, color paint coating to match the color of the walls etc.

Weatherproof enclosure shall be of the high impact water resistant to IP 56.

## 2.04 HORIZONTAL CABLING

Category 6 UTP cable shall be used for all voice and data horizontal cabling from the telecommunication outlet to the communication room/closet, wired in star-topology with PVC insulated and sheathed 24 gauge solid copper conductor 4-pair unshielded twisted pair with following color-coding:

Pair 1: Tip-White with Blue markings
Ring-Blue with optional White markings
Pair 2: Tip-White with Orange markings
Ring-Orange with optional White markings
Pair 3: Tip-White Green markings
Ring-Green with optional White markings
Pair 4: Tip-White with Brown markings
Ring-Brown with optional White markings

The electrical transmission characteristics shall meet or exceed the following:

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| Category 6 | |
|---|---|
| DC Resistance Imbalance | < 50mOhm |
| Insulation Resistance | > 500MOhm min |
| Delay Skew | < 1.25ns |
| Characteristic impedance 1-250 MHz | 100 Ohm |
| DC resistance (max) | < 200m Ohm |

Transmission characteristics of the cable are as follows:

| Transmission Characteristic Of Cat - 6 Cable | | | | | | |
|---|---|---|---|---|---|---|
| Frequency in MHz | Attenuation in dB/100m | NEXT Loss in dB at 100m | PS NEXT in dB at 100m | ELFEXT in dB at 100m | PSELFEXT in dB at 100m | ACR in dB |
| 1 | 2.1 | 66.0 | 64.0 | 66.0 | 64.0 | 98.2 |
| 10 | 6.0 | 59.3 | 57.3 | 50.0 | 47.0 | 94.7 |
| 16 | 7.6 | 56.2 | 54.2 | 45.9 | 43.0 | 93.2 |
| 20 | 8.5 | 54.8 | 52.8 | 44.0 | 41.0 | 92.4 |
| 31.25 | 10.8 | 51.9 | 49.9 | 40.1 | 37.1 | 90.4 |
| 62.5 | 15.5 | 47.4 | 45.4 | 34.1 | 31.1 | 82.4 |
| 100 | 19.9 | 44.3 | 42.3 | 30.0 | 27.0 | 77.7 |
| 250 | 33.0 | 38.3 | 36.3 | 22.0 | 19.0 | 62.3 |

## 2.05 BACKBONE CABLING

Backbone cabling from the system equipment (Data Centre) to the telecommunication closet shall be connected with optical fibre cable in Star-topology with failover optical fibre link to connecting floor.

Intra-building (campus) backbone shall be of a construction appropriate for outdoor condition, with water-blocking gel and high-density polyethylene sheath for environmental protection, and armour for mechanical protection.

Fiber-optic cabling shall comply with ANSI X3. 166-1990 and shall be multi-strand 50/125 micron for core/cladding diameter multimode graded index fibres, tightly jacketed. The sheath shall be colored orange or some other bright color to help distinguish fibre media from other wiring. The cable construction should be metal free to avoid requirement of grounding, lightening protection etc.

All fiber optic cables used in the backbone system shall conform to the following transmission characteristics:

- No. of Fibers: 06
- Core Diameter: 50.0±3.0µm
- Numerical Aperture: 0.200±0.0015
- Cladding Diameter: 125.0±2.0µm
- Core-Clad Concentricity: ≤3.0µm
- Cladding Non-Circularity: <2.0%
- Core Non-Circularity: ≤5%
- Coating Diameter: 245±5µm
- Coating-Cladding Concentricity: <12µm
- Operating Wavelengths: 850 and 1300 nm

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- Bare Fiber Attenuation: 2.5 dB/km per 850 nm
  0.8 dB/km per 1300 nm
- Cables Fiber Attenuation: 3.5 dB/km per 850 nm
  1.5 dB/km per 1300 nm

Minimum bending radii criteria should be followed for the installation of the Optical fibre cable. The outdoor fibre-optic cable shall be properly interfaced indoors with indoor cable by using fusion or mechanical splicing, in a proper housing.

For voice applications, cabling form the main cross-connect (telecommunication/ equipment room) to the telecommunication room/ closet cabinet shall be wired with PVC insulated and sheathed 100 ohm 24 gauge solid copper conductor multi-pair unshielded twisted pair (UTP).

## 2.06 VOICE CABLING

A 25 Pair PTCL cable shall be terminated at MDF (Main Distribution Frame) .The PTCL cabinet shall be wired, with PVC insulated and sheathed 100 ohm 0.6 mm sq solid copper conductor multi-pair Unshielded twisted pair.

The multi-pair cable shall be formed into blinder groups of 25-pairs, congregated as such, and shall be identifiable by surrounding distinctly coloured blinder strings or ribbons. All binder groups are to be collectively enclosed by a protective sheath consisting of a thermoplastic jacket, with an optional underlying metallic shield. The pair twists of any one pair shall not be exactly the same as any other pair within the same 25-pair binder group: a minimum of one twist per 305 mm is required. Each conductor shall be colour-coded in accordance with the 10-colour industry standard colouring scheme for 25-pair, 50-conductor cables.

## 2.07 CROSS CONNECTING HARDWARE & PATCH CORDS

Copper Cross-Connect / Patch Panels at the Communication rooms / Data centre shall be RJ-45 type unshielded modular jack type for data and IDC-block type for voice applications, suitable for 19‖ (EIA RS-310) rack-mounting.

The modular jack panel shall be based proprietary IDC-block for termination of the 23 gauge solid copper conductor and 8-pin modular (RJ45) jack. IDC field shall be wired internally with 8-pin modular jack field on the front of the panel through printed wiring board (PWB) interconnections with provision for ensuring continuity of electrostatic shield.

Patch panel shall be suitable for field termination of 23 gauge solid copper conductors. The block shall have a colour-coding scheme to aid in cable pair placement, and a series of fanning strips at rear of each RJ45 jack for dressing cables. The terminating block shall have a minimum life of 500 insertions without permanent deformation, and a reliability of one contact failure in 10,000 connections. The patch shall be IDC based.

Voice Cross-connect patch cables shall meet minimum performance requirements for voice cabling. The patch cables shall be either 1 or 2 pair flexible copper insulated with high-density polyethylene and jacketed in PVC. Each patch cord shall be terminated at one end with RJ45 connector and with one or two plugs at the other end for 1 or 2 pair cable respectively. It shall be possible to patch upto two voice services into one data outlet without termination of cable pairs or jumpering.

110 patch panels shall be suitable for field termination of 22-24 gauge solid copper conductors. The block shall have a colour-coding scheme to aid in cable pair placement, and a series of fanning strips for dressing cable pairs. The terminating block shall have a minimum life of 500 insertions without permanent deformation, and a reliability of one contact failure in 10,000 connections. The patch shall be 110-block IDC based.

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Fiber-optic patch panel in the Data centre shall be high-density SC type terminating maximum number of cables in least space. The Data centre patch panel to be equipped with SC connectors, which have permanent cabling, connected at the rear and present forward facing SC sockets allowing patching with cords fitted with SC connectors. Provision shall be available for storing extra length of fibers and their dressing.

Optical fibre patch panels on the floors shall be equipped with SC-type connectors which have permanent cabling connected at the rear and present forward facing SC sockets, allowing patching with cords fitted with SC connectors at both ends. Patch panels shall have sliding drawer construction to facilitate easy access to the terminated fibers. Provision shall be available for storing extra length of fibers and their dressing.

All fiber-optic cable shall be terminated with SC connectors. Connectors shall have plastic bodies with ceramic ferrules, with a maximum loss of 0.5dB for each pair of mated connectors.

i) The cross-connect / patch panel shall be co-located with active networking hardware in a floor-mounted cabinets (with 50% of the space available for active networking hardware). The panel shall be equipped with a lockable glass door, backboards, modular frame, brackets, wire-management accessories, retaining troughs, cable guides, labels, fans & power sockets etc. 1-U (U=44mm) cable management (Horizontal patch cable Run) shall be placed between every 1-U Patch Panel. Vertical Ring Runs shall be used for managing cables / patch cords vertically as necessary.

Data Cross-connect patch cables shall meet the minimum performance requirements for the horizontal cable. Flat, non-twisted cable shall not be used. The cable shall be manufactured from 4-pair 26 gauge tinned copper stranded flexible conductors with electrostatic shield, insulated with high-density polyethylene, and jacketed with PVC. Each patch cord shall be terminated at both ends with 4-pair / 8-pin RJ45 plugs designed to be pushed on and pulled off the main cross-connect (patch) panel to facilitate administration.

Fiber-optic patch cords shall be provided for connections with active networking hardware. The cable shall be manufactured from single pair optical fibre. Each patch cord shall be terminated at switch end with SC or MT-RJ connector plugs designed to be pushed on and pulled off the active device as applicable to facilitate administration. The patch panel end shall be terminated with duplex SC connectors.

## 2.08 MAIN DISTRIBUTION FRAME

Main Distribution Frame shall be 100 Pair version, compact, wall mounted and fabricated from steel. It shall have pre-drilled holes for fixing all Distribution System Equipment including IDC 100 pair bases, horizontal and vertical cable management panels, drip trays, screws to fix these items for ease in installation. The frame shall accommodate 4 pair IDC connectors, catering for all cable termination requirements for voice cabling.

## 2.09 SURGE PROTECTION

Demarcation block / network interface shall be used at the building entrance to provide lighting and surge protection. These shall be of the indoor type with IDC-type connectors and solid-state/gas protector units. Surge protection blocks shall have provision to permanently by-pass the load in case of continued presence of high voltage on the line. Surge protection block design shall be such that in case surge protector is removed for replacement, input & output sides become isolated.

# 3. EXECUTION

## 3.01 INSTALLATION

a) System Documentation/Shop drawings:

After the award of work prior to supply/installation of any equipment the Contractor shall submit comprehensive System Documentation with shop drawings (in duplicate) of cable layout plan of each floor, after studying cable trunking plans (issued in the tender document), for the approval of the Engineer before executing the work.

The documentation package shall include:

i. The marked-up floor plans/shop drawings showing outlet locations, associated numbering, DF locations, and major run paths and risers, schematics.

ii. A synopsis of the numbering scheme

iii. The cross connect log in hard copy and software based

iv. A list of major components and their place in the network

v. Any ancillary supporting documentation

The Contractor is required to submit a sample of assembled cable, connectors, raceway and accompanying specification sheets prior to installation for approval of quality, workmanship and materials.

**b) Cabling**

- All cable installation and termination shall adhere to the provisions in TIA/EIA 568 and TIA/EIA TSB40-A.
- Cables only shall be laid in already laid GI trunks under the supervision & guidance of contractor (Voice/Data Structured Cabling System Supplier).
- All other Voice/Data Structured Cabling equipment shall be installed & cable termination shall be undertaken by the Contractor (Voice/Data Structured Cabling System Supplier).
- The Contractor's staff undertaking installation & termination shall be certified installers trained & certified by the manufacturer of structured cabling equipment.
- Cabling shall be routed and installed at a sufficient distance from equipment and power cabling that may generate high levels of electromagnetic interference. Cables shall be laid without joints or splices (except where approved), stress-free with a minimum bend radius of at least 10 times the cable diameter, and shall be tied at regular intervals and dressed neatly. The twist of all cable shall be maintained as closely as possible to the point of mechanical terminations.
- The length of each station cable shall not exceed 90 meters. Station cable is defined as that length of cable from the back of the workstation outlet to the back of the Patch Panel or connecting block in the telecommunications closet. Station cable shall be a continuous run of cable with no splices, bridges, or other discontinuities.
- Maintain cable twist-rate at all termination points. The amount of cable untwist shall be no more than 15mm. Do not strip back the cable jacket any more than is necessary to punch down the individual conductors.
- All 110 connections shall be installed using a single 110 punch down tool and all terminations shall be trimmed flush with connector blocks.

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- Leave enough cable (2 meter at each outlet and 5 meters at the backboard, rack, or hub locations) to allow proper cable connections.
- Station cable that runs outside the walls shall be in surface-mounted raceway, cable tray, or conduit.
- Minimum 20mm conduit shall be installed in all walls and shall be run to above ceiling line. Terminate all conduits with plastic bushings. A minimum 200 ts polyline pull string shall be provided the entire length of each conduit.
- When conduit runs from room to room, provide a metered tape and a minimum 200 ts polyline pull string to run the entire length of the conduit.
- Conduit bends must be long, sweeping bends with radius not less than: 6 times the internal diameter of conduits 50mm or smaller; or, 10 times the internal diameter of conduits larger than 50mm.
- Each cable installation shall be accompanied by a minimum 200 ts polyline pull string.
- Cables shall not be tie wrapped to electrical or gas conduit. Maintain a minimum 100mm separation between low voltage cabling and electrical raceways, lights, etc.
- D-rings will be provided and mounted to route the station cables at the backboard locations (& in chase locations as designated on the drawings).
- Enough cable slack will be provided to neatly route the station cable through the ¯ID‖ rings to the appropriate 110 type block.
- No communications or data circuit shall be run in the same conduit or raceway with power conductor except where the raceway is separated by a divider.
- Cable routing shall follow the routes dictated by the detail while avoiding locations of high RFI/EMI radiation or adverse environmental conditions.
- All plastic type molding must be anchored to the wall with the appropriate type of wall screw every 1.5 meters.
- The Voice/Data cable plant shall be grounded and bonded in accordance with ANSI/TIA/EIA-607.
- All cable coming from ceiling shall be placed in cable trunks.

### c) Numbering Scheme

An intelligent numbering scheme is to be used in the cable plant for identification of the cable. The numbering scheme may be based on the cable plant itself and not any technological or physical aspect of the building it supports. The numbering scheme breaks into three areas:

- Horizontal Cabling
- Backbone Cabling
- System Equipment
  - Horizontal Cabling

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Label each cable, user outlet, and patch panel (or punch block) with a designation developed to the following formula at each end of the run:

DF# - Group # - Channel

Where DF# is the terminating distribution frame the cable connects to (¯00‖ typically designated the Building Distributor / MDF). Group # is sequential in each DF and typically represents a patch panel or punch block and Channel # is sequential within the group, as indicated by the logical or physical channel numbering on the components.

- **Backbone Cabling**

  Label each riser cable; user outlet and patch panel (or punch block) with a designation developed to the following formula each end of the run:

  ODF# - TDF# - Cable# - Channel

  Where ODF# is the distribution frame from which the cable originates, TDF# is the distribution frame in which the cable terminates, Cable # is sequential between each DF and Channel # is sequential within the cable, as indicated by the logical or physical channel numbering on the components. It is not required where the cable represents a single physical channel of communications.

- **System Equipment**

  Use the following designation formula for each piece of network equipment that is represented directly or through some type of patch panel:

  Device# - Group# - Port#

  Where Device# is sequential for each device in a DF, Group # is sequential in each device and represents a chassis card or other logical group and Port# is sequential within the group is indicated by the logical or physical channel numbering on the group components.

- **Cross Connect Log:**

  As the final procedure in any network installation, the certified installer should provide a set of cross connect logs for each DF in the system. A cross connect log shall be simple hard copy and software-based log documenting the cross connections of rack and wall mounted termination components (i.e., patch cables or cross wires). It follows a simple ¯from-to‖ format utilizing the numbering scheme to identify interconnecting ports.

  A numbering/labeling scheme different from suggested above may be submitted.

**d) Labeling**

All labeling for cables, outlets & patch panels shall be carried out in accordance with the E1A/TIA-606 standard and FCO Standard ¯Cable Labeling Standard 1.0‖ (QSTD 500), and as per manufacturer recommendation.

Patch Panel, Wiring Blocks, Cables, etc. shall be clearly, neatly and indelibly labeled at both ends of each cable itself and on the faceplate at both ends on which the connectors are mounted, and as per numbering scheme submitted / approved alongwith system documentation.

## 3.02 DRAWINGS & DOCUMENTATION

Four (4) separate sets of detailed System Record Documents including items listed above in 6 and test results including hard copies of all link characteristics for each cable run shall be submitted.

## 3.03 TESTING

The Contractor shall provide all testing equipment, required including an industry standard tester at required frequencies, and conduct tests and measurements on the entire system including IDC and St connecting hardware, outlets and other components, to demonstrate compliance with

specification and certify the system. Printouts for each cable (in quadruplicate) shall be provided showing all the parameters laid down in EIA/TIA TSB 36 and 40, including an acceptable ‗loss budget' for the type of equipment being connected.
Copper FTP Cabling: Tests shall include, but not be limited to, continuity, polarity, open/short/split/reversed circuits (pairs) Near-end Cross Talk (NEXT), cable attenuation, ambient noise levels on signal pairs, Signal to Noise ration (SNR), pair continuity, cable parameters, identification of split pairs, etc.

Optical fibre cabling: Each individual fibre optic link shall be tested in both directions for attenuation as well as with an Optical Time Domain Reflect meter (OTDR).
Hard copies of test results shall be delivered in quadruplicate to the Engineer, with System Record Documents as in 8) above.

## 3.04 WARRANTY

The system shall have a Registered minimum 20-year Extended Product Warranty and a 5-year System Assurance. All associated paperwork, including a copy of the registration document & certificate shall be provided to the Employer upon completion of the project.

## 3.05 TRAINING

The Contractor shall train the Employer's personnel in the use, operation, and administration/management of the system.

A. Contractor shall provide all necessary testing equipment to test all cables.
   1. Each cable terminating in a station jack shall be tested from the telecommunications closet with a 4-pair wire tester. The tester shall verify continuity, faults, reversals, swaps and pairing.

   2. Each Category 5 cable link shall also be tested for near-end and far-end crosstalk and attenuation up to and including 100 Mhz and shall be verified for acceptable length.

   3. A hard copy of the test results for each cable run shall be provided to the Employer. Acceptable test results shall be agreed upon by the Employer and contractor prior to testing. It is the contractor's responsibility to replace or repair any cables, connectors or jacks which test outside the agreed-upon ranges.

B. Before the system is approved by the Engineer, the Contractor will be required to ―walk-through‖ the installation with the Employer and verify proper installation and conformance to specifications, drawings, and other agreed upon, written details.

C. All cable-related documentation and As-Built Drawings will also be required for reviewing purposes at this time.

## 3.06 INFORMATION TO BE FURNISHED BY CONTRACTOR

The following data must be submitted with the bid:

1. Detailed technical literature and specifications with Make & model numbers of equipment offered (including all accessories) with BOQ item numbers clearly marked against each item.
2. Contractor, where appropriate, will require to demonstrate the items detailed in the proposal. All these demonstrations/ presentation shall simulate actual environment. Contractor shall bear all cost of said presentations / demonstrations.
   A request from Client for said demonstrations does not imply that the contractor has been short-listed for award of the said work.
3. A detailed list of compliance / deviations from contract conditions and technical specifications shall be submitted. If none is submitted it shall be assumed that there are no deviations.

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4. Any proposed changed in design / equipment shall be offered separately
5. Authorization certificate of the contractor as an agent to backup specified 20 years system performance warranty from manufacturer.

Certificates of authorized installers from manufacturer certifying that contractor's personnel have been trained & certified for system installation.

# FIRE ALARM SYSTEM

# FIRE ALARM SYSTEM

## 1 SUMMARY

The work under this section consists of supplying, installing, testing and commissioning of all material and services of complete Fire Alarm System as stated herein, as shown on Tender drawings and as given in the Bill of Quantities.

The Contractor will discuss the Fire Alarm System layout with the Engineer and coordinate at site with other services for exact route, location and position of electrical lines and equipments.

The Fire Alarm System with accessories shall also comply with the general specifications for Electrical Works and with other relevant provisions of the Tender Documents.

## 2 GENERAL

All outlet boxes shall be considered part of the devices installed on them and shall be supplied along with the devices.

The system shall operate on 24 VDC from a battery charger with standby batteries. The incoming supply shall be 230 VAC from emergency circuit.

The Addressable Fire Alarm System shall be used for early detection, warning and control function in case of fire. The system shall monitor and report the status of manual call points and automatic fire detectors.

- All the Intelligent Sensors detailed above shall incorporate the following facilities:-
- Up to 99 intelligent Sensors and modules may be connected to each loop.
- The Sensors shall be ceiling - mount and shall include a twist-lock base.

The Sensors shall provide a means of test whereby they will simulate an alarm condition and report that condition to the Control & Indicating Equipment (C.I.E.) Such a test may be initiated at the Sensor itself (by activating a magnetic switch) or initiated remotely on command from the C.I.E.

The Sensors shall provide address setting on the Sensor head using decimal switches. Addressable Sensors that use binary address setting methods, such as a dip switch, code cards or soft addressing are not acceptable. The Sensors shall also feature an internal identifying code that the C.I.E. shall use to identify the type of Sensor.

The Sensors shall provide dual LED's. Both LED's shall flash under normal conditions, indicating that the Sensor is operational and in regular communication with the C.I.E. Both LED's may be placed into steady illumination by the C.I.E., indicating that an alarm condition has been detected. If required, the flashing mode operation of the Sensor LED's shall be controlled through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED.

The Sensor sensitivity shall be set through the C.I.E., and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the C.I.E. on a time-of-day basis.

- Using software in the C.I.E. the sensors may automatically compensate for dust accumulation and other slow environmental changes that may affect their performance.
- Complete layout of Fire Detection & Alarm system showing locations of all fire zones, and bells zones in two different colors.

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- Standby battery specification, including ampere-hour capacity Voltage per Cell, number of Cells, and the battery type.
- Operating and maintenance instruction in BLACK color.
- Emergency instructions in RED color.
- Name, address & telephone number of the servicing contractor.

The characters of written instructions shall be minimum 6 mm high.

The fire alarm system shall be master slave type with all panels connected in a network via fiber optic cable. The panel shall have provision for fiber optic loop card, with the panel located in the BMS room designated as the Master Fire Alarm Panel which shall have the capability of displaying the status of the entire facility on its LCD panel.

All fire alarm panels shall have the capability of connecting to a central BMS software and provide monitoring capability of the entire facility from a single Master FACP and BMS software. Connectivity with the BMS software shall be over non proprietary protocol. The FACP for each building shall have the capability of communicating with other panels on the network via fiber optic cables.

## 3 APPLICABLE STANDARDS/CODES

The following standards & codes shall be applicable for the materials covered within the scope of this section:

| | | |
|---|---|---|
| NFPA 70 | - | National Electrical Code |
| NFPA 72 | - | National Fire Alarm Code |
| NFPA 101 | - | Life Safety Code |
| NFPA 5000 | - | Building Construction & Safety Code. |

Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by under writers laboratories (UL) & shall bear the UL label. Equivalent DIN or British Standard shall also be acceptable.

## 4 MATERIAL

### 4.1 Analogue Addressable Fire Alarm Control Panel

The system shall be easily configured using „plug-in‘ addressable loop drivers and communication modules. Further „plug-in‘ modules shall be available to allow the expansion of programmable inputs and outputs.

The control panel shall support up to two analogue addressable loops. The control panel shall transmit alarm and trouble conditions to fire alarm panel repeater installed in administration building.

The Power Supply shall operate on 230 VAC, 50 Hz, and shall provide all necessary power for the control panel.

In the event of a mains electrical failure, the fire alarm control panel shall have the capability of being supported in its intended state by standby batteries for six hours. The fire alarm control panel shall be fitted with an integral battery charger, current limited with DDP for 24 V lead acid

batteries. The battery charger must be capable of being up-graded in capacity to facilitate larger systems.

The panel shall incorporate as standard 1 x failsafe fault output and 1 x fully programmable fire output each with volt-free changeover contacts rated at 24 VAC/DC, 1 Amp maximum. It shall be possible to add further programmable changeover relay contacts to the panel via the detection loop and the dedicated RS485 peripheral bus.

The panel shall have 14 general panel status LED's. An alphanumeric liquid crystal display shall give 80 characters of information on a 2-line display. The display will be illuminated to aid viewing under dim ambient light conditions.

Zonal fire indicators (LED's) and zonal fault/test/disabled (LED's) shall be provided. It shall be possible to increase the number of zonal fire and fault/test/disabled LED's simply by ―plug-in‖ extender cards.

An on-board alphanumeric keypad with 17 keys shall allow the complete control and configuration of the system. Alternatively the panel shall be programmed using PC based upload/download software.

Four separate push buttons shall provide control of Sound Alarms (Evacuate), Silence/Resound, Mute/Accept and Reset, and shall be located adjacent to the main LED indication.

A dedicated RS232 port shall also be provided for upload/download of configuration data via the manufacturer's standard PC programming tool.

User Control Levels :- The fire alarm control panel shall have three user control levels.

At all three levels, the LED displays shall indicate the condition of the installation, the zone LED's shall indicate the location of any fire alarm or fault and the alphanumeric display shall provided detailed fire alarm or fault information.

**Level 1 -** All displays shall be functional, but the front panel controls shall be inhibited.

**Level 2 -** All displays and all front panel controls shall be functional. Changes to the system configuration shall not be accessible at this level. User Level 2 shall be reached by entering a unique 4 digit password from level 1.

**Level 3 -** All front panel controls shall be functional and full system configuration and programming shall b possible. User level 3 shall be reached by entering a unique 4 digit password from either level 1 or level 2. User level 3 shall be for use by the system installer / maintenance contractor.

A level 2 password shall not allow access to level 3 functions.

Up to 10 level 2 passwords shall be definable from level 3.

A program integrity option shall display the panel software version along with ROM and RAM checksums. The RAM checksum shall alter whenever the configuration is changed. For example, the checksum figure shall change when either adding or removing devices or changing text assignments. After the final configuration has been entered the program integrity shall be checked and the RAM checksum figure recorded.

**Day Modes:** The fire alarm control panel shall have the ability to automatically invoke different operating modes according to the time of day. Each mode shall have adjustable start and finish times. Outside of the designated start and finishing times, the panel shall revert to normal operation. The operating modes will consist of:

**Delayed mode:** During the day or night the alarm signal from the detection points shall be immediately recognized and identified on the panel display, but no outputs switched on until staged timers have expired.

**Sensitivity mode:** Shall allow smoke and temperature detectors to use different pre-alarm and fire alarm thresholds during day and night mode.

**Verification mode:** Shall allow smoke detectors to tolerate transient alarms according to the programmed verification delay time during either day or night.

**Control Module:** Addressable Control Modules shall be provided for fan shut down and other auxiliary control functions, the control module may be set to operate as a Volt Free relay contact.

The indicating circuit may be wired for a maximum of 1 Amp (inductive) or 2 Amps of Resistive A/V Signal operation, or as a Volt Free Contact (Form C) Relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to ensure that 100% of all auxiliary relay or indicating circuits may be energized at the same time on the same loop.

The Control Modules shall provide address setting on the module using decimal switches. The modules shall also feature an internal identifying code that the C.I.E shall use to identify the type of module.

A magnetic test switch shall be provided to test the module without opening or short line its wiring. The isolator module shall be installed on the semi flush mounted box.

The fire alarm panel shall have the capability to connective to other fire alarm panels via standard networking protocols (BAC-NET etc.) and to central BMS system via Ethernet network either through a copper or a fiber based physical connectivity layer. A central / Master Fire Alarm Control Panel shall be connected to the fire alarm network which shall have the capability to be installed anywhere on the network and shall display the status of the entire fire alarm network / system

**Isolator Module:** Isolator Modules shall be provided to automatically isolate circuits on a loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the loop. At least one isolator module shall be provided at either side of each zone of the building.

If a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the affected segment of the loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section of the loop.

The Isolator Module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.

The Isolator Module shall be installed on the semi flush mounted box. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steady to indicate that a short circuit condition has been detected and isolated.

**Event Log:** The fire alarm control panel shall store the last 500 events. It shall be possible to se the event log to either ¯diagnostic‖ or ¯normal‖ mode. Normal is the default mode.

When in diagnostic mode the log shall record every event including single response failures from a device. The diagnostic mode shall aid the engineer to determine spurious or transient fault conditions including loop wiring and detector problems, particularly if these are intermittent.

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**Displayed Identification** :- During normal panel operation, when the fire alarm control panel is operating correctly, the LCD display shall display a message that identifies the system installer / maintenance company, this display shall feature up to 20 characters.

If a fault occurs on the fire alarm control panel the LCD display shall automatically show a telephone number to call for assistance, this display shall feature up to 20 characters.

**Cause-and-effect programming: -** The panel shall provide a flexible way of performing cause-and-effect programming. This shall include mapping individual detectors and call points to outputs as well as mapping outputs relative to zones in alarm.

In the event of a fire alarm, the indications shall be as follows:

The location text message of the alarms on the system shall be shown on the main panel and on remote Honeywell XL1000 panel.

The zone alarm LED indicators on panels shall illuminate to show the zones in alarm on the overall system.

In case of a fire alarm in a particular zone relays and sounders of that zone shall operate.

The system control functions shall operate as follows:

The standard system control functions (sound alarms, silence / resound, mute / accept and system reset) shall operate on a peer-to-peer basis. For example, a sound alarms (manual evacuation) raised at any panel, or active remote annunciators (fire system repeater), shall cause all of the panels to sound alarms and all sounder outputs shall activate.

## 4.2 Addressable Manual Call Points

Addressable Manual Call Points shall be provided to connect to the Fire alarm Control and Indicating Equipment (C.I.E.) loops.

The Manual Call Points shall, on command from the Control and Indicating Equipment (C.I.E.), send data to the C.I.E. representing the state of the manual switch. Manual Fire alarm Call Points shall use a key operated test without the need to break the glass, and shall be designed so that after Emergency operation, they cannot be restored to normal use except by the replacement of the glass element.

Manual Call Points shall be constructed of flame retardant plastic with clearly visible operating instructions provided on the glass. The word FIRE shall appear on the front of the Call Points.

Manual Call Points shall be suitable for semi-flush mounting as required.

The Manual Call Points shall provide address-setting means using decimal switches.

## 4.3 Photoelectric Smoke Sensors

Smoke Sensors shall be addressable devices and shall connect to C.I.E. loop.

The Sensors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the C.I.E. send data to the C.I.E. representing the analogue level of smoke density.

## 4.4 Ionisation Type Smoke Sensors

Smoke Sensors shall be addressable devices and shall connect to one of the control panel loop.

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The Sensors shall use the dual-chamber ionisation principal to measure products of combustion and shall, on command from the C.I.E. send data to the C.I.E. representing the analogue level of products of combustion.

### 4.5 Grade 2 Heat Sensors

Heat Sensors shall addressable devices and shall connect to one of the C.I.E. loop.

The Sensors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the C.I.E., send data to the C.I.E. representing the analogue level the temperature at the sensor.

### 4.6 Grade 1 Heat Sensors

Heat Sensors shall be addressable devices and shall connect to one of the C.I.E. loop.

The Sensors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the C.I.E. send data to the C.I.E. representing the analogue level the temperature at the sensor.

### 4.7 Sounder

Sounder shall be addressable device and shall connect to the C.I.E loop. Dual sound path shall allow a wide angle of sound distribution with a constant sound level. Self test facility shall allow all sounders to be tested from the control panel by one person. Sounder shall provide high output 90 dBA to 112 dBA at 1 m.

### 4.8 Wiring and Cabling

Wiring and cabling of Fire and alarm system shall be carried out in metallic (rigid or flexible) conduits wherever exposed. Consuits concealed in structure shall be PVC type of appropriate size. Screened 1.5 $mm^2$ with LSF PVC over covering a fire resilient cable to BS7629 or 2x2x0.8 mm dia twisted cable as recommended by manufacturer for the loop wiring, 2Cx2.5 $mm^2$ cable shall be used for circuiting of conventional devices. Wiring for notification devices shall be done separately with 2Cx2.5sqmm cable of similar fire resilient specifications

All wires and cables shall be color-coded, tagged and checked for open, short or ground faults. No transposition of colours will be permitted. All wiring shall be made on terminal blocks of proper size and type for the services involved. Cable joints shall only be allowed on the detector bases.

## 5 INSTALLATION

### 5.1 Fire Alarm System Equipment

The installation of Fire Alarm system equipment shall be in strict accordance with the manufacturer's instructions/recommendations and these specifications.

The testing of Fire Alarm equipment shall be in compliance with the relevant standards and regulations. During testing of equipment, emphasis shall be laid on the following:

- Operational Safety
- Regular functioning of the system and devices
- Protection against false alarms

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Various detectors like smoke, heat, manual call point etc. shall be subjected to the basic tests and sensivity tests. The automatic detectors shall be tested in various ways to check real and false alarm behaviours.

### 5.2 Wiring and Cabling

Wiring and cabling of fire alarm system shall be carried out as per instructions given in 'Low Voltage Cables' section of these specifications.

## 6 TRAINING

A training session shall be presented by a fully qualified, trained representative of the equipment manufacturer/supplier who is thoroughly knowledgeable of the specific installation. The training shall be given to personnel responsible for operation and maintenance of the system.

The training session shall include but not limited to the following:

6.1 Detailed explanation of wall charts as mentioned in Article 2.0 of this section.

6.2 Function of each control switch

6.3 Periodic operational testing of panel/devices.

6.4 Maintenance of fire log book supplied by manufacturer.

6.5 Actions to be taken upon receiving following signals:

6.5.1 False alarm indication

6.5.2 Trouble on any initiating or indicating zone

6.5.3 Common alarm or common trouble indication

6.5.4 Low battery voltage indication

6.6 Field modifiable programming.

## 7 MEASUREMENT AND PAYMENT

### 7.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion of all work specified herein and/or as shown on the Tender Drawing related to the item.

### 7.2 Automatic Detectors and Manual Call Points

7.2.1 **Measurement:** Measurement shall be made for the total number of each type of automatic detectors and manual call points acceptably supplied and installed by the Contractor as complete unit.

7.2.2 **Payment:** Payment shall be made for the number of units measured as **provided** above at the contract unit price and shall constitute full compensation for supplying, installing, testing and commissioning of each type of the automatic detectors with base and manual call points including mounting accessories.

### 7.3 Sounder

7.3.1 **Measurement:** Measurement shall be made for the number of Sounder acceptably supplied and installed by the Contractor as complete unit.

7.3.2 **Payment:** Payment shall be made for the number of units measured as provided above at the Contract unit price and shall constitute full compensation for supplying, installing, testing and commissioning of all the Sounder including all mounting accessories like outlet boxes etc.

### 7.4 Fire Alarm Control Panel

7.4.1 **Measurement:** Measurement shall be made for fire alarm control panel including all related equipment as given in BOQ such as power supply, relays, batteries, etc. alongwith all accessories acceptably supplied and installed by the Contractor as complete job

7.4.2 **Payment:** Payment shall be made for the complete job measured as provided above **at** the contract unit price and shall constitute full compensation for supplying, installing, testing and commissioning of fire alarm control panel alongwith all accessories.

### 7.5 Wiring of Fire Alarm Loops / Conventional Device

7.5.1 **Measurement:** Measurement shall be made for the total number of wiring of fire alarm loops / conventional device circuit appropriate size G.I. conduit acceptably supplied and installed by the Contractor as a complete unit.

7.5.2 **Payment:** Payment shall be made for the number of units measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, connecting testing and commissioning fire alarm loops/conventional device circuit wiring including G.I. conduit, junction boxes and all accessories.

# PUBLIC ADDRESS SYSTEM (IP BASED)

# PUBLIC ADDRESS SYSTEM (IP BASED)

## 1 SUMMARY

The work under this section consists of supplying, installing, connecting, testing and commissioning of all materials and services of the complete Public Address Systems as specified herein, or as given in the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the P.A. System layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the loudspeaker and microphone cables and equipment.

The Public Address System with accessories shall also comply with the General Specifications, Section and with other relevant provision of the Tender Documents.

## 2 GENERAL

Public Address System shall be used for lectures, seminars and symposium rooms as appropriate. The Contractor is free to offer any design of equipment which in his opinion will be equal to or better than the requirement in this specifications where an alternative offer is proposed, the Contractor shall furnish details of such alternatives to enable their merits to be assessed. Architectural drawings shall be referred for the frequency dependency of finishing materials. Contractor shall submit to Engineer detailed calculations and layout drawings for approval. Public Address System shall be IP based and connected to LAN Cloud / Network.

## 3 APPLICABLE STANDARDS AND CODES

The following standards and codes shall be applicable for the materials covered within the scope of this section:

a) IEC 60849 - Sound System for Emergency Purpose, EVAC Compliance
b) EN 60065 - Safety of Electrical Equipment
c) EN54-16 – European Standard of Voice Alarm System
d) IEC 65 - Safety of Electrical equipment

Relevant publications of ANSI, NEMA and IEC.

## 4 EQUIPMENT

### 4.1 Two Way Loud Speakers

The Two Way Loudspeaker shall comprise coated paper conceal loudspeakers and a horn tweeter supplying a wide angle dispersion of 70° vertical and 180° horizontal. The drive units shall be a damped and extended frequency response over a range of 180 Hz to 18 kHz. Sensitivity shall be a minimum of 97 dB @ 1 meter 1 watt test signal bandwidth 100 Hz 10 Khz, included shall be a factory mounted 100 volt line transformer with 3 dB power taps. All units shall be tested in accordance with BS 6840 parts the enclosure shall be constructed in metal and epoxy powder coated to match. An 30 watt/100 volt line pre-mounted transformer shall provide 3 dB power taps via a recessed selector switch situated at the base of the unit. The unit shall be supplied with mounting brackets.

### 4.2 Wall Loud Speaker

The wall loudspeaker shall have following minimum technical specifications.

Rated power : 6 Watts

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| | | |
|---|---|---|
| Transformer tapping | : | 6 / 3 / 1 / 1.5 Watts |
| Frequency range | : | 180 - 18,000 Hz. |
| SPL @ 1 m, 1 Watt, | | |
| 1 kHz | : | 85 dB. |

### 4.3 Ceiling Loudspeaker

Loudspeaker suitable for flush mounting in false ceiling with round / square cover plate as required with following minimum technical specification.

| | |
|---|---|
| Rated output power | 6 W |
| Sound pressure level | 91 dB at 1 meter distance at 1000 Hz |
| Frequency response | 220 – 20,000 Hz |
| 100 V transformer | easily adjustable in three solder less step to 1/1, ½ and ¼ outlet. |

### 4.4 Main Equipment

Main equipment shall comprise pre-amplifier, power amplifier, two zone output module, mixer selector, free standing rack and all accessories required for the complete P.A. system. Amplifier module shall be capable of providing power output of 60W into a load impedance of 160 Ohms, 100 volt line. They may be used to provide individual 60 watt amplifier channels in which case they shall input/driver circuitry, they may be connected in parallel to provide amplifier channels of 120, 180, or 240 watts using 2, 3 or 4 modules. It shall be possible to configure modules in different combination within the mainframe. The modular amplifier shall have following specifications:

| | | |
|---|---|---|
| - | Power bandwidth | 100 Hz to 15 kHz |
| - | Distortion | Less than 1% at rated power |
| - | Noise | 80 dB max. |

Speaker in rack shall be provided for monitoring of amplifier system. The cabinet shall comply with IEC 297 and shall be totally enclosed. Side and rear panels shall be removable, cable entrances shall be at the rear, top or bottom side.

A module mounting frame with hinges shall be provided. The surface finish shall be of black colour. The frame shall be anodized aluminium sections. Each cabinet shall be equipped six 230 V / 50 Hz socket outlets.

All incoming and outgoing cables shall be terminated to a connection panel with adequate terminals for the different sized microphone and loudspeaker cables.

### 4.5 Microphone

Moving coil / dynamic microphone suitable for mounting or table stand and floor stand with ON/OFF switch shall have following minimum technical specifications:

| | |
|---|---|
| Frequency response | 30 – 16,000 Hz |

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| | |
|---|---|
| Output level at 1 kHz | - 70 dB |
| Cable length | 10 m. |
| Terminal of Cable | Phone Plug |
| Directivity | Unidirectional |

### 4.6 Loudspeaker Cable

Multi-core insulated and sheathed cable with minimum cross section of 1.5 sq.mm. for the copper conductors. The conductor insulation and the sheath shall be polyvinyl chloride (PVC) and shall be rated for a minimum of 300/500 V. The cable insulation shall be rated for at least 85°C. the cable shall be suitable for the installation in conduits or on trunking.

### 4.7 Microphone Cable

The conductors with a diameter of 0.5 mm shall be of stranded copper wires. Two conductors shall be twisted to a pair which is screened with tinned copper wires. The conductor insulation and the sheath shall be polyvinyl chloride (PVC).

The insulation resistance shall be a minimum of 100 mega Ohm / km. The cables shall be suitable for the installation in conduits, ducts or on trunking, number of pair as required.

### 4.8 Conduits/Pipes and Accessories

The specifications for conduits/pipes and accessories shall be same as given in section 'Conduits & Pipes' of these specifications.

## 5 INSTALLATION

The installation of the Public Address systems shall be strictly in accordance with the manufacturer's recommendations and instructions and in consultation/approval of the Engineer.

## 6 MEASUREMENT AND PAYMENT

### 6.1 General

The Contractor bid amount against each Bill of Quantities item as given below shall include design, supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the Tender Drawings related to the item.

### 6.2 Loud Speakers

6.1.1 **Measurement:** Measurement shall be made for the total number of each type loud speakers and integral tapping transformers with accessories acceptably supplied and installed by the Contractor as a complete unit.

6.1.2 **Payment**: Payment shall be made for the number of units measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing connecting, testing and commissioning of the loud speakers and integral tapping transformer including all cabling, conduiting and all mounting accessories etc., complete in all respects.

## 6.3 Main Equipment

**6.1.3 Measurement:** Measurement shall be made for the Main Equipment with accessories acceptably supplied and installed by the Contractor as a complete job.

**6.1.4 Payment:** Payment shall be made for the complete job measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, connecting, testing and commissioning of the Main Equipment including all cabling and mounting accessories etc., complete in all respects.

## 6.4 Microphone

**6.1.5** Measurement: Measurement shall be made for the total number of microphones with accessories and cables acceptably supplied and installed by the Contractor as a complete unit.

**6.1.6 Payment**: Payment shall be made for the number of units measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, connecting, testing and commissioning of the microphones including all cabling.

## 6.5 Wiring of Loud Speakers/ Microphone cables

**6.1.7 Measurement:** Measurement shall be made for the total running feet of wiring cables for loudspeaker circuit and microphone cable including appropriate size concealed PVC conduit acceptably supplied and installed by the Contractor.

**6.1.8 Payment:** Payment shall be made for the total running feet measured as provided above at the contract price each and shall constitute full compensation for supplying, installing, testing and commissioning of wiring cables for loudspeaker circuit and microphone cables including appropriate size PVC conduit and all accessories, complete in all respects.

# ACCESS CONTROL SYSTEM

# ACCESS CONTROL SYSTEM

## 1 SUMMARY

This section specifies the minimum acceptable requirements on the quality, performance and standard for the Card Access Control System. The Contractor shall supply, install, test and commissioning the complete Card Access Control System (CACS) as per Specifications and Drawings.

The primary purpose of the system is to provide security control to the premises by preventing unauthorized persons from entering certain areas. It shall ensure that proper measures shall be taken by generating alarms and displaying reaction text to be taken by the security officer.

Issuing and management of Access Control Cards shall be done at the Card Management Station. As cards are issued, the card management station updates the cardholder database of the CACS.

The system shall make provision to interface to the Closed Circuit Television System (CCTV) to trigger the particular CCTV camera(s) when an alarm is being triggered.

The system shall make provision to interface with Fire alarm system to release the entire escape door under Card Access Control System when a fire alarm is activated.

The system shall make provision to interface with Building Management System to trigger any other necessary system as per any pre-set protocol.

## 2 COMPONENTS

a) System Programming Software

b) Real-time Access Control, Output Control and Alarm Monitoring System

c) Real-time Transaction and Report Printer

d) Card Readers

e) Door Controllers

f) Electromagnetic Locks

g) Door Contacts

h) Exit push button

i) Cabling

j) Access cards.

k) Emergency break glass.

l) Other equipment necessary to provide a complete access control system.

## 3 SUBMISSION

All technical submissions shall be approved by the Consultant/Engineer prior to the respective stages of construction.

As a minimum requirement, the submission shall include the following:

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a) Equipment submission with manufacturer's data and any supported technical literature.
b) Sample submission including all types of Cards, Readers, Locks, Door Contacts and Exit button, Break glass, Controller, etc.
c) Wiring schematic diagram.
d) Shop Drawings for field equipment showing the co-ordinate routing of cable routings and details on the fixing of the readers, locks, door contacts and Exit button.
e) Technical literature of any other equipment required for integration with other systems.

## 4 OPERATION REQUIREMENTS

The card reader, upon accepting a valid card, shall allow the card holder to gain access. The card reader shall also denied entry if the card is invalid. It shall have different audio & visual indicators for both access permit and denied entry.

The card reader controller shall, at the same time, send the access information to the central computer unit to update the record, with display of card number, holder name, reader location and time/date of access.

In case of tail gate entry, when one gets entry without logging card, on return he may not be allowed to get out. (This case scenario is, if Card Readers are applied on both sides of door)

Log shall be maintained for each number of attempts.

The access shall have enough time to allow a single person to enter. If a door is held open for an extended time, an alarm shall be generated and sent to the central computer unit for event logging. The access duration shall be programmable from 5 to 180 seconds.

If a card is not used or is invalid for any reason and the door is forced open, then a signal to intrusion alarm's central computer unit for event logging.

The event report shall be able to printout automatically or manually set by the security officer.

The central computer unit shall monitor each individual card reader and provide an alarm if the reader has gone off-line, providing information on which reader has stopped and its location.

## 5 SYSTEM DESCRIPTION

As an access control system, access will be controlled by the identifications of the following:
A. Facility or site code.

B. Card Number

C. Date and Time

D. Reader Location

System response time to grant an authorization or denial shall not exceed 1 second from time of card read.

As an alarm monitoring system, the alarms shall be monitored simultaneously with card access. Alarms shall be reported to the security room and FCC room by means of a real-time display, alarm printout, and an audible or visual signal.

The contractor shall appoint a specialist subcontractor for the supply, installation, commissioning and training of Online Access Control System. The proposed products shall be supported by a local distributor / installer with sufficient experience in the industry. Only the equipment approved by the engineer, shall be delivered to site or installed. The system shall include control panels, smart cards and card readers, magnetic door contacts and magnetic locks as indicated on the drawings. The system shall include any additional accessories or parts those are not indicated on these

specifications and drawings shall be considered and included to form a fully operational system to the satisfaction of the engineers.

The system shall include proximity cards and proximity readers as indicated on the drawings.

Different control panel configurations for one, two, four six and eight door controlling shall be available to allow various combinations of card/card reader or keypad inputs, relay outputs, and alarm inputs to maximize system hardware flexibility. Panels can be combined to provide the exact number of inputs and outputs required for each application. All panels shall support a fully distributed architecture with all real-time processing done at each panel. Each door shall be provided with a 2 door controller.

The Access Control System shall provide the following minimum features:

Instant response to Card Read within 0.25 seconds and reporting on access control monitoring within 2.0 seconds.

No degradation of system performance in case of a communication loss. All time zones access levels and holiday schedule shall remain operational on such occasion.

No loss of transaction for system history flues. All panels automatically shall switch to buffer mode, capable of storing 10,000+ events per panel.

Each panel shall represent one "Intelligent Controller" in the distributed processing network. Each Controller shall use an Intel 80C88 microprocessor as its engine.

Information shall be downloadable to the panels using either a PC or LAN network. A Computer shall not be necessary for panel operation and may be taken off-line if required, once the system information has been downloaded to the panels.

For basic system requirements a PC shall simply be used as a Terminal or Window into the System, History Data Logging Device and Data Manager.

All panels shall have a built-in reset timer (watchdog circuit) that automatically reboots the panel in the event that the processor is interrupted by a transient surge. When a system processor is reset, it shall automatically request a parameter down load from the Master panel and reboot to its proper working state. If the Master panel is reset, it shall automatically request a parameter download from the PC or LAN. When the Master is a modem location, it shall automatically dial the PC or LAN, via modem, and receive the parameter downloaded.

The doors shall operate Fail safe/Fail Secure as per Engineers requirements on site.

# CCTV SYSTEM (IP BASED)

# CCTV SYSTEM (IP BASED)

## 1 GENERAL

### 1.01 INTRODUCTION

A. Surveillance CCTV system is required to ensure effective surveillance of an area as well as create a tamperproof record for post event analysis. The System shall provide an online display of video images on full HD monitors located in Central control rooms.

B. System should facilitate viewing of live and recorded images and controlling of all cameras by the authorized users present in the LAN.

C. System should provide inter-operability of hardware, OS, software, networking, printing, database connectivity, reporting, and communication protocols. System expansion should be possible through off-the-shelf available hardware.

D. Equipment with better specifications shall be accepted.

### 1.02 WORK DESCRIPTION

A. The work under this section consist of supplying, installation, testing and commissioning of complete CCTV System, along with wiring and conduiting as stated herein and as per BOQ. All the equipment shall be UL Listed. The contractor shall furnish with the tender bid, complete details of equipment, material etc.

B. This Section specifies the minimum acceptable requirements on the quality, performance and standard of the Close Circuit Television (CCTV) System.

C. The System shall be used for general surveillance and security monitoring of public and dedicated areas.

D. The System shall be constructed in accordance with the manufacturer's specification. Any equipment modifications to meet the Specification shall not be acceptable.

E. All equipment shall be current model, no replacement problem of components.

F. The CCTV System shall, in addition to the compliance of minimum requirement stipulated in this Specification and as shown on the Drawings, allow at least 20% spare on both software and hardware facilities including a camera wiring termination panel for future expansion.

G. All cablings shall be laid in conduits and trunkings. No cabling shall be run exposed.

H. The CCTV system shall be equipped with multi-screen controller to view several camera pictures on a single monitor. It shall be protected by password for accessing to the system programming to prevent tampering and misused by unauthorized personnel.

I. All programmed settings for the controller shall be stored in non-volatile memory and render no re-programming is necessary in the event of a power failure.

J. The CCTV system shall provide whatever interfacing requirement to complete the installation.

### 1.03 SYSTEM INTERFACE

CCTV system shall be integrated with Fire alarm system, Emergency Voice Evacuation system, Access control system and Building Management system for sequential operations and status monitoring.

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A. Interface with Access Control System (CACS)

i. The CCTV system shall provide input interfacing to the CACS. The CACS shall provide ―Normally Closed‖ dry contact output (free voltage) to the CCTV console. The CCTV system shall then connect these CACS alarm outputs to its input module.

ii. Upon receiving an ―open contact‖ signal from the CACS system, the CCTV controller shall immediately display the pre-programmed camera to the monitor. At the same time, the Digital Video Recorder (DVR) shall also be recorded in normal speed.

B. Interface with Electrical System

i. A power supply shall be provided for the CCTV system inside the security room and FCC room. The Contractor shall be required to provide his own power distribution system to all central control and monitor equipment inside the security room and FCC room.

ii. A 13A non-switched fused connection unit shall be provided for each CCTV camera by the Contractor.

C. Interface with Intrusion Alarm System

i. The CCTV system shall provide input interfacing to the Intrusion Alarm System. The Intrusion Alarm System shall provide ―Normally Closed‖ dry contact output (free voltage) to the CCTV console. The CCTV system shall then connect these Intrusion Alarm System outputs to its input module.

ii. Upon receiving an ―alarm contact‖ signal from the Intrusion Alarm System, the CCTV controller shall immediately display the pre-programmed camera to the monitor. At the same time, the Digital Video Recorder (DVR) shall also be recorded in normal speed.

D. Interface with Fire Alarm System

i. The CCTV system shall provide input interfacing to the fire alarm system. The Fire Alarm System shall provide ―Normally Closed‖ dry contract output (free voltage) to the CCTV console. The CCTV system shall then connect these Fire Alarm system outputs to its input module.

ii. Upon receiving an ―alarm contact‖ signal from the Fire Alarm System, the CCTV controller shall immediately display the pre-programmed camera to the monitor. At the same time, the Digital Video Recorder (DVR) shall also be recorded in normal speed.

iii. The interface with Fire Alarm System shall share the interfacing signal for Public Address System given by the Fire Alarm System.

## 1.04 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

B. As a minimum requirement, the submission shall include the following:

i. Equipment submission with manufacturer‘s data.

ii. Sample submission including camera housings, mounting brackets with accessories for flexible conduit entry, cables, lens covers for lift camera, etc.

iii. Drawings for field equipment showing the co-ordinate routing of cable routings and details coverage calculation on the selection of lens for each camera.

iv. Builder's works requirements.

## 2. SYSTEM DESCRIPTION

The scope of the work includes the installation, testing and commissioning the complete CCTV system as described herein and as shown on the plans. The system shall include Network Video recorders (NVR/CAMERA SERVER), Digital CCD Colour video Cameras with individual IP address (Dome Cameras, Fixed type cameras, PTZ cameras, PTZ controller), LCD screens, wiring, termination, electrical boxes, and all other necessary material for a complete operating system.

### 2.1 General Specifications:

1. Proposed CCTV system shall be an open standard based integrated system with IP network centric functional and management architecture aimed at providing high-speed manual / automatic operation for best performance.

2. System shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors at Central Control Room and simultaneously record all the cameras after compression using H.264/MPEG 4 or better standard. Joystick or Mouse-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

3. System shall have combination of Digital CCD Colour video Cameras with individual IP address with Fixed or P/T/Z Lens, Network Video recorders (NVR/CAMERA SERVER), Storage for recording, Application software, Colour Video Monitors, Keyboards with Joystick controllers / Mouse-Keyboard; software based Video Matrix Switcher, workstation for System Administration / Management / Maintenance etc.

4. Network Video Recorder shall offer both video stream management and video stream storage management. Recording frame rate & resolution in respect of individual channel shall be programmable.

5. System should ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes.

6. System shall provide sufficient storage of all the camera recordings for a period of 30 days or more @ 25/12 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras (extended capacity of cameras i.e. present capacity + 25 %).

7. System shall use a combination of IP enabled fixed and PTZ cameras. The video shall be compressed using H.264 / MPEG-4 or better standard and streamed over the IP network.

8. The recording resolution and frame rate for each camera shall be user programmable.

9. The Area under surveillance shall be monitored and controlled from Central Control Room(s) through workstations and Joystick controllers.

10. Surveillance CCTV System shall operate on 230 V, 50 Hz single -phase power supply. Power for all the equipment will be conditioned using on-line UPS with minimum 30 minutes or more back up. If any equipment operates on any voltage other than the supply voltage and supply frequency, necessary conversion/correction device for supply shall be supplied along with the equipment.

11. All the control equipment e.g. servers, NVR/CAMERA SERVER, Storage backup device etc. shall be provided in standard Racks.

12. All the indoor cameras & control equipment shall be suitable for operation from 100 deg C to 400 deg C and relative humidity up to 80 % non-condensing. Cameras & other equipment, meant for

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outdoor installations, shall be suitable to work from (-) 10deg C to (+) 50 deg C with RH up to 90% non-condensing.

### 2.2 System Requirements:

1. All Indoor / Outdoor cameras shall be min. 3MP resolution with auto iris and varifocal lens as per site requirement.

2. All Indoor / Outdoor cameras shall be min 3MP resolution with auto iris and varifocal lens and IR to provide better view in night conditions with IP65/66 environmental enclosure.

3. PTZ cameras shall be min 6MP resolution with varifocal lens, high SNR, IR, wide dynamic range, 30x optical zoom and true day/night feature with weather proof enclosure.

4. Housing of cameras meant for indoor use shall be of IP 42 rating whereas outdoor camera housing shall be of IP 65 or better rating. These must be integrated by the camera manufacturer.

5. System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording so that these can be used as evidence at a later date, if so desired.

6. All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.

7. Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as\][] in any desired combination must be available in the system.

8. Facility of Camera recording in CIF, 2CIF, 4 CIF, D1 as well as in any combination i.e. any camera can be recorded in any quality – Selective or Group of cameras must be available in the system.

9. System to have facility of additional camera installation beyond the originally planned capacity.

10. In order to optimize the memory, while recording, video shall be compressed using H.264 / MPEG-4 or better standard and streamed over the IP network.

11. System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.

12. The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) on CD or DVD or USB Storage. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

13. System shall have provision of WAN connectivity for remote monitoring.

## 3. CENTRAL CONTROL & MONITORING EQUIPMENT

All central hardware equipment shall be housed in a control console. This section shall indicate the major central equipment required for the operation and control of the CCTV System. Exact system configuration and quantity of equipment shall be as indicated on the Drawings and as required to complete the installation.

### 3.01 CCTV MONITOR

The video monitor shall be colour type with operating controls up-front and recessed screw driver set-up controls for easy, in-rack adjustments front panel controls shall be rotary knobs to control CONTRAST, V-HOLD, H-HOLD and BRIGHTNESS. The resolution shall be better than 700 lines

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with a bright 12 KV display. A regulated supply, front panel adjustable DC restoration, fast acting AFC, and solid state circuitry shall be included for high picture quality and reliability. Picture tube shall be 9/13/16 inch (as required) diagonal 90 degrees deflection, aluminized, integral implosion protection. The colour system shall be CCIR PAL with scanning of 625 line, 50 fields / seconds.

The video input shall be 0.5 to 2.0 Vp-p composite video, sync negative. Tow ‗F' connectors and 75 ohm termination switch on rear panel for loop through operation shall be provided.

**21‖ Composite CCTV Monitor (Color)**

KEY FEATURES

- 21‖ Clean High Picture Quality Colour Monitor / LED TV 43‖
- Horizontal resolution 450 TV liens
- Environmental Metal Case preventing electromagnetic interference
- High picture quality through comb filter
- Automatic Colour Switching Systems (NTSC/PAL) through Flat Square Type CRT
- Built-in One-way Audio Speaker
- S-VHS input for Separate Y-C Signals
- Free Voltage (AC 90V ~ AC 260V)

SPECIFICATIONS

- CRT Type 21 inch colour / LED TV 43‖
- Resolution more than 450 TV Lines
- Television System NTSC / PAL (Auto)
- Video Input 2 Video Input / S-VHS Video Input
- Video Output 2 Video Output
- Power Source AC90V ~ 260V, 50 ~60Hz
- Power Consumption 72W
- Environment Temperature -10°C ~ 40°C
- Humidity 0 ~ 90% RH
- Connector Video Input BNC Type
- Audio Input RCA Type
- S-VHS Mini Din

**3.02 Network Video Recorder**

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- RAID-5 protected, all-in-one, fully featured video management solution for up to 128 channels
- Out-of-the-box IP video management solution with up to 24 TB storage capacity
- Robust, secure operation – instant real time access to video
- Instantly find what you are looking for
- Advanced user and alarm management feature

| | |
|---|---|
| Processor | Intel Xeon Quad Core X3430 (2.4 GHz, 8MB Cache, 95 W) |
| Cache memory | 1 x 8 MB Level 2 cache |
| Memory protection | ECC un-buffered |
| Max front side bus | 1333 MHz |
| Memory installed | 4 GB, DDR3-1333 ECC UNB (2 x 2 GB) |
| Storage type | 8 Trays: 3.5-inch SATA |
| Hard Drives Capacity | Up to 24TB, 2 TB SATA/300 7.200 RPM 3.5¯ |
| SAS RAID card | 2108 based SAS/SATA RAID card - 8 internal ports/low profile-PCI-E |
| Graphics card | AMD FirePro V3900 1 GB, low profile |
| Sound card | Creative Sound Blaster PCI sound card |
| OS drive | Intel SSD 320 OVR, 80 GB (MLC) |
| DVD writer | Yes, Internal |
| Accessories | Keyboard EN-US (QWERTY), Mouse standard |
| Raid Protection | Raid 5 Protected |
| AC input rating | 100 to 240 V / 9 to 4 A / 50 to 60 Hz |
| Actual output wattage from power supply | 256.44 W |
| Efficiency of power supply | 0.88 |
| Max Power consumption | 378 W approx. |
| Power factor | 0.95 |
| System AC input VA requirement | 306.75 VA |
| Form factor | 2HU rack mount |
| Power supply | 740 W Platinum Level, Redundant |

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| | |
|---|---|
| USB ports | 4 USB 2.0 |
| Network | Dual Intel 82574L Gigabit LAN |
| Dimensions (H x W x D) | 89 x 437 x 648 mm (3.5 x 17.2 x 25.5 in) |
| Weight | 23.6 kg (52 lb) |
| Operating temperature | +10 °C to +35°C (+50 °F to +95 °F) |
| Non-operating temperature | -40 ° C to +70 ° C (-40 ° F to +158 °F) |
| Operating relative humidity | 8 to 90% (non-condensing) |
| Non-operating relative humidity | 5 to 95% (non-condensing) |
| ONVIF support | Yes |
| Other Features | Advanced user and alarm management, Instant real time access to video |

### 3.03 Network Switch

- The Security Contractor shall supply and install TCP/IP Network Switches at distributed locations and in main Control Room with cabling and patching into security devices.
- The Network Switches shall be of the following types: Core Switch, Distribution switches and Access Level Switches as required.
- The Security Contractor shall coordinate all security network switch locations to ensure network connectivity is provided at each location.
- All network equipment shall be by a major brand name manufacturer. Network equipment that is not designed and built by major brand name manufacturer will not be considered as an approved equal for alternate system.

Requirements

- Core Switch and Distribution switch shall be of enterprise-class which provides high availability, scalability, security, energy efficiency, and ease of operation with features IEEE 802.3 at Power over Ethernet Plus (PoE+) configurations, optional network modules, and redundant power supplies.
- Core Switch shall be of Gigabit 12/24 Ports 10/100/1000 Mbps non-PoE type with maximum throughput capacity available at each port.
- The distribution switch shall be a Fiber switch of 12 / 24 ports Gigabit Ethernet Small Form-Factor Pluggable (SFP) ports.

Main features of Core & Distribution switches shall be:

- Four optional uplink network modules with GE or 10GE ports shall be available with core switch.
- Dual redundant, modular power supplies and fans.
- Media Access Control Security (MACsec) hardware-based encryption

- Flexible NetFlow and switch-to-switch hardware encryption with the Service Module uplink
- Open Shortest Path First (OSPF) for routed access in IP Base image
- IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware
- USB Type-A and Type-B ports for storage and console respectively and an out-of-band Ethernet management port
- In addition to the above features, the Core& Distribution switches shall have Stack Power™ technology which is an innovative feature for sharing power among stack members
- The switches shall have Stack Wise Plus technology for ease of use, which enable high 64 Gbps of throughput capacity at its ports.
- Access switches hall be designed to form part of a unified, highly resilient switching system over a LAN.
- Access Switch shall meet or exceed the following design and performance specifications:
    - 24 or 48 Ethernet Manageable Cat-VI ports with Power over Ethernet.
    - Access Data switches to provide Ethernet connectivity to field devices must have at least 10/100mpbs throughput.
    - At-least 2 small form-factor pluggable (SFP) transceiver-based Gigabit Ethernet ports
    - Support for Internet Group Management Protocol, version 2 (IGMPv2)
    - Stackable with high-speed stacking bus
    - Support QoS
    - Support for multicasting
    - Enterprise-class intelligent services delivered to the network edge
    - Full dynamic IP routing
    - Redundant Power Supply

### 3.04 Copper Patch Panels

- The patch panel shall meet or exceed the requirements for Class E requirements described in ISO/IEC 11801 2.2 2011.
- The patch panel system components shall meet or exceed the requirements for channel /component-level performance for ISO Class F.
- The panels shall feature multiple wiring configurations, mounting standoffs for cable management bars, color-coded front window labeling, and a termination standoff for patch panel earthing / grounding.

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- The panels shall be made of min. 14 gauge steel. The plastic elements shall be fire-retardant.
- The panel shall be offered in 12, 24, or 48port configurations as per requirement.
- The patch panel shall be compatible with 19" equipment racks, cabinets or wall mount brackets.
- The patch panel shall be equipped with front labeling space to facilitate port identification.
- Copper patch cords of appropriate size and any other accessories required shall also be provided with patch panels.

### 3.05 PAN/TILT CONTROL

The pan-and-tilt control shall be unit with auto pan. One version shall be available for 24-VAC pan-and-tilt control and one version shall be available for 240-VAC control. Manual pan-and-tilt operation shall be controlled by a joystick, and auto pan shall be controlled by a latching pushbutton. The control shall have a power indicator light on the front panel. Input power shall be 240 V, 50 Hz, and the control shall be housed in a modular enclosure designed for either desk-top or rack-mount use.

### 3.06 PTZ Controller Joystick / Keyboard

- Control matrix, DVR, and IP video products with one keyboard
- Soft keys allow for product-specific menus
- Backlit keys and easy-to-read displays
- Simplified system programming with an intuitive interface
- Multilingual support
- Plug-and-play with Switchers, DVRs, Multiplexers, and IP solutions
- Optional PC software supports customizable Allegiant command script programming

| | |
|---|---|
| Operating Voltage | 12-15 VAC/DC (supplied by one, or a combination of Allegiant switchers, NVR, System4 Multiplexers, or optional power supply) |
| Power | 5 W nominal |
| Allegiant Signal | RS-485: 2-wire, 9600 Baud, 8 bits, no parity, 1 stop bitRS-232: 3-wire, 9600 Baud, 8 bits, no parity, 1 stop bit |
| Mux/DVR Signal | RS-485: 2-wire, 19,200 Baud, 8 bits, no parity, 1 stop bit |
| Terminal Mode Signal | RS-232: 3 wire, 9600 Baud, 8 bits, no parity, 1 stop bit |
| Console Signal | RS-232 RTS/CTS handshaking,19,200/57600 Baud, 8 bits, no parity,1 stop bit |

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| | |
|---|---|
| Allegiant,Mux/DVR Connector | RJ-11 data/power |
| Console Connector | Male, 9-pin D-sub |
| Enclosure | Splash-resistant |
| Operating Temperature | 0°C to 50°C (32°F to 122°F) |
| Storage Temperature | -20°C to 50°C (-4°F to 122°F) |
| Relative Humidity | 10%-90%, non-condensing |
| Allegiant | Backwards compatible with all systems using variable speed protocol (CPU firmware 5.3 and higher, released 6/94) |
| Requirements | Pentium-class PC with Windows NT, 2000, XP, Vista (32 or 64 bit), or Windows Server 2003;One (1) serial port; Latest firmware |

## 4. FIELD EQUIPMENT

### 4.01 CCTV CAMERA

A. Cameras shall be manufactured to give maximum performance and dependability for indoor and outdoor applications. The proposed camera for lifts shall be hidden in false ceiling or hidden behind a mirror or dark glass panel.

B. The cameras shall have high quality printed circuit boards for maximum durability and ease of service. The camera shall be low light level type, interline transfer charge coupled device type to allow operation in any practical security application.

C. The camera shall have beam and electrical focus control and be accessible without cover removal. All other adjustments shall not be possible without cover removal.

D. Line lock synchronisation shall be applicable for all cameras. The Contractor is responsible to ensure all cameras can be adjusted by line lock tools, if necessary.

E. Each camera shall incorporate a vertical control pot that shall adjust the vertical phase of the signal from 0º to 360 º. The unit shall be used to maintain the camera signals vertically in phase so that the applications of vertical interval switching, sequential camera scanning, Digital Video Recorders can be adopted to the system. Switching from one camera output to another shall be crisp clean and immediate without visual disturbance characteristics of random interlace.

F. The system used shall be CCIR 625 lines 50 fields per second. The solid state camera shall be tropically finished, tamper and weatherproof with CCD image sensor and automatic light compensation suitable for operation at minimum illumination of 1 lux, with f1.4 lens and having a resolution of at least 380 lines at centre. The minimum S/N ration shall not be less than 43dB.

G. Camera number identification shall be integrated into the camera and a particular location code shall be assigned for each camera. No two cameras shall bear the same code in the whole development.

**IR Dome Camera 1080P**

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## A. General Characteristics:

1. The camera shall be capable of operating in an indoor or an outdoor environment.
2. The camera shall be easy to install.
3. The camera shall provide an automatic zoom/focus lens wizard to remotely zoom and focus the lens.
4. The camera shall offer 1080p resolution at 30 fps.
5. The camera shall provide direct network connection using H.264 and JPEG compression and bandwidth throttling to efficiently manage bandwidth and storage requirements while delivering outstanding image quality.
6. The camera shall have a mechanical IR cut-off filter for true day/night switching.
7. The camera shall use Intelligent Dynamic Noise Reduction technology to remove noise artifacts and reduce the bitrate by up to 50% (giving reduced bandwidth and storage requirements).
8. The camera shall utilize Intelligent Defog (IDefog) to effectively remove the haze from the picture and provides a better visibility.
9. The camera shall accept power via Power over Ethernet (IEEE 802.3af compliant).
10. The camera shall offer tamper and intelligent motion detection.
11. The camera shall offer two-way full duplex audio communication.
12. The camera shall provide configurable scene modes that give optimized settings for distinct applications.
13. The camera shall provide eight independent, fully programmable privacy mask areas.
14. The camera shall utilize pixel-by-pixel analysis to automatically compensate for bright areas of a high contrast scene without having to define a window or area.
15. The camera shall have a CVBS analog video output for hybrid operation.
16. The camera shall be rated to IP66 standard against water and dust ingress.
17. The camera shall be rated to IK10 impact protection.
18. The camera shall have a built-in active infrared illuminator.

## B. Image processing and compression

1. The camera shall use a progressive scan CMOS image sensor.
2. The camera shall produce a resolution of 1920 x 1080 pixels with a 16:9 aspect ratio.
3. The camera shall be fitted with a board-mounted automatic varifocal lens.
4. The camera shall have a wide dynamic range.
5. The camera shall have a high sensitivity.

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6. The camera shall have an automatic electronic shutter.

7. The camera shall be capable of capturing and storing images using the following compression standards:

   a. H.264 MP (Main Profile)

   b. M-JPEG

8. The camera shall offer a region of interest to zoom into a specific area of the full image.

9. The camera shall allow a region of interest to be sent in a separate stream so it is possible to view both an overview and a detail at the same time.

**C. Night Vision (Infrared)**

1. The camera shall have a LED high efficiency IR array for effective night vision.

2. The camera shall allow adjusting intensity of IR output to fit with the environment.

**D. Audio**

1. The camera shall offer G.711, AAC and L16 audio compression (live and recording).

2. The camera shall offer full duplex audio communication.

**E. Network Video**

1. The camera shall provide direct network connection.

2. The camera shall allow full camera control and configuration capabilities over the network.

3. The camera shall deliver video over a 10/100 Base-T, auto-sensing, half/full duplex, RJ45 Ethernet connection.

4. The camera shall comply with the IEEE 802.3af Power over Ethernet standard.

5. The camera shall conform to the ONVIF Profile S standard.

6. The camera shall support AutoMDIX.

**F.Image Posting**

1. The camera shall offer periodic JPEG image posting to an FTP server or a Drop box account.

**G. Access Security**

1. The camera shall offer three levels of password protection.

2. The camera shall support 802.1 x authentications using a RADIUS (Remote Authentication Dial In User Service) server.

3. The camera shall store a SSL certificate for use with HTTPS.

4. The camera shall be capable of being independently AES encrypted with 128-bit keys.

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### H. Recording and Storage Management

1. The camera shall support iSCSI devices to allow video stream to be recorded directly to an iSCSI RAID array.
2. The camera shall support iSCSI storage targets to enable the camera to function as a conventional DVR.
3. The camera shall have a microSD card slot.
4. The local storage feature shall be capable of storage for Automatic Network Replenishment (ANR).
5. Local Recording: Continuous recording, ring recording, alarm/events/schedule recording.

### I. Alarm Handling Features:

1. The camera shall provide the capability on alarm to display up to a 31 character, programmable alarm message.
2. The camera shall provide email alarm messaging with optional JPEG posting.

### J. Embedded Video Content Analysis

1. The camera shall be VCA enabled.
2. The camera shall be capable of processing and analyzing video within the camera itself, with no extra hardware required.
3. The camera shall be capable of detecting and sending alarms for abnormal events.
4. The camera shall allow users to set up to 10 separate profiles and switch profiles based on a day/night or holiday schedules.
5. The camera shall offer MOTION+ video motion analysis that uses an algorithm based on pixel change.
6. The MOTION+ feature shall include extended tamper detection capabilities.

### K. Surveillance Software

1. The camera shall be accessible from a web browser, from Video Management System, or via third-party software.
2. The camera shall be accessible from the Security System mobile app.

### L. Technical Specifications

| Power | |
|---|---|
| Input voltage | +12 VDC or Power-over-Ethernet (48 VDC nominal) |
| Power consumption | 6.3 W max. |
| PoE | IEEE 802.3af (802.3af Type 1) Power level: Class 2 |

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| Sensor | |
|---|---|
| Sensor type | 1/2.7-inch CMOS |
| Total sensor pixels | 1952 x 1092 (2MP) |

| Video performance - Sensitivity | |
|---|---|
| Sensitivity – (3200K, reflectivity 89%, F1.5, 30IRE) | |
| Color | 0.24 lx |
| Mono | 0.05 lx |
| With IR | 0.0 lx |

| Video performance - Dynamic range | |
|---|---|
| Dynamic range | 76 dB |

| Video streaming | |
|---|---|
| Video compression | H.264 (MP); M-JPEG |
| Streaming | Multiple configurable streams in H.264 and M-JPEG, configurable frame rate and bandwidth. Regions of Interest (ROI) |
| Overall IP Delay | Min. 120 ms, Max. 340 ms |
| GOP structure | IP, IBP, IBBP |
| Encoding interval | 1 to 30 [25] fps |
| Encoder regions | Up to 8 areas with encoder quality settings per area |

| Supported Video resolutions (H x V) | |
|---|---|
| 1080p HD | 1920 X 1080 |
| 720p HD | 1280 x 720 |
| D1 4:3 (cropped) | 704 x 480 |
| SD upright (cropped) | 400 x 720 |
| 480p SD | Encoding: 704 x 480; Displayed: 854 x 480 |

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| Supported Video resolutions (H x V) | |
|---|---|
| 432p SD | 768 x 432 |
| 288p SD | 512 x 288 |
| 240p SD | Encoding: 352 x 240; Displayed: 432 x 240 |
| 144p SD | 256 x 144 |

| Video functions | |
|---|---|
| Day/Night | Color, Monochrome, Auto |
| Adjustable picture settings | Contrast, Saturation, Brightness |
| White Balance | 4 automatic modes, manual mode and measure |
| Shutter | Automatic Electronic Shutter (AES);<br><br>Fixed shutter (1/25[30] to 1/15000) selectable; Default shutter |
| Backlight compensation | On/off |
| Noise reduction | **Intelligent Dynamic Noise Reduction** with separate temporal and spatial adjustments |
| Contrast enhancement | On/off |
| Sharpness | Sharpness enhancement level selectable |
| Intelligent defog | **Intelligent Defog** automatically adjusts parameters for best picture in foggy or misty scenes (switchable) |
| Privacy Masking | Eight independent areas, fully programmable |
| Video Analysis | **MOTION+** |
| Other functions | Image mirror, Image flip, Pixel counter, Video watermarking, Display stamping, Scene modes, Location |

| Night vision (IR version only) | |
|---|---|
| Distance | 15 m (50 ft) |
| LED | 10 LED high efficiency array, 850 nm |
| IR intensity | Adjustable |

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| Optical | |
|---|---|
| Lens type | 3 to 10 mm Automatic Varifocal (AVF), DC Iris F1.3 – 360, IR corrected |
| Lens mount | Board mounted |
| Day/Night | Switched mechanical IR filter |
| Horizontal field of view | 36° - 117° |
| Vertical field of view | 20° - 61° |
| Adjustment | Motorized zoom/focus |
| Iris control | Automatic iris control |

| Input/output | |
|---|---|
| Analog video out | SMB connector, CVBS (PAL/NTSC), 1 Vpp, 75 Ohm |
| Audio line in | 0.707 Vrms max, 10 kOhm typical, jack connector |
| Audio line out | 0.707 Vrms at 16 Ohm typical, jack connector |
| Alarm input | 1 input |
| Alarm input activation | Short or DC 5V activation |
| Alarm output | 1 output |
| Alarm output voltage | 30 VDC, max. load 0.5 A |
| Ethernet | RJ45 |

| Audio streaming | |
|---|---|
| Standard | G.711, 8 kHz sampling rate<br>L16, 16 kHz sampling rate<br>AAC-LC, 48 kbps at 16 kHz sampling rate<br>AAC-LC, 80 kbps at 16 kHz sampling rate |
| Signal-to-Noise Ratio | >50 dB |
| Audio Streaming | Full-duplex / half duplex |

| **Local storage** | |
|---|---|
| Internal RAM | 10 s pre-alarm recording |
| Memory card slot | Supports up to 32 GB microSDHC / 2 TB microSDXC card. (An SD card of Class 6 or higher is recommended for HD recording) |
| Recording | Continuous recording, ring recording. alarm/events/schedule recording |

| **Software** | |
|---|---|
| Unit Configuration | Via web browser or **Configuration Manager** |
| Firmware update | Remotely programmable |

| **Network** | |
|---|---|
| Protocols | **IPv4, IPv6, UDP, TCP, HTTP, HTTPS, RTP/RTCP, IGMP V2/V3, ICMP, ICMPv6, RTSP, FTP, Telnet, ARP, DHCP, NTP (SNTP), SNMP (V1, MIB-II), 802.1x, DNS, DNSv6, DDNS (DynDNS.org, selfHOST.de, no-ip.com), SMTP, iSCSI, UPnP (SSDP), DiffServ (QoS), LLDP, SOAP, Dropbox, CHAP, digest authentication** |
| Encryption | TLS 1.0, SSL, DES, 3DES, AES (optional) |
| Ethernet | 10/100 Base-T, auto-sensing, half/full duplex |
| Connectivity | Auto-MDIX |
| Interoperability | **ONVIF** **Profile S**; GB/T 28181 |

| **Environmental** | |
|---|---|
| Operating temperature | -30 ºC to +50 ºC (-22 ºF to +122 ºF) |
| Storage temperature | -30 ºC to +70 ºC (-22 ºF to +158 ºF) |
| Humidity | 20% to 90% relative humidity (non condensing) |

## 4.02 IR Weather Proof Bullet Camera 1080P

A. General Characteristics:

1. The camera shall be easy to install.

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2. The camera shall offer 1080p resolution at 30 fps.

3. The camera shall provide direct network connection using H.264 and JPEG compression and bandwidth throttling to efficiently manage bandwidth and storage requirements while delivering outstanding image quality.

4. The camera shall have a mechanical IR cut-off filter for true day/night switching.

5. The camera shall use Intelligent Dynamic Noise Reduction technology to remove noise artifacts and reduce the bit rate by up to 50% (giving reduced bandwidth and storage requirements).

6. The camera shall utilize Intelligent Defog (IDefog) to effectively remove the haze from the picture and provides a better visibility.

7. The camera shall accept power via Power over Ethernet (IEEE 802.3af compliant).

8. The camera shall offer tamper and motion detection.

9. The camera shall offer two-way full duplex audio communication.

10. The camera shall provide configurable scene modes that give optimized settings for distinct applications.

11. The camera shall provide eight independent, fully programmable privacy mask areas.

12. The camera shall utilize pixel-by-pixel analysis to automatically compensate for bright areas of a high contrast scene without having to define a window or area.

13. The camera shall have a CVBS analog video output for hybrid operation.

14. The camera shall have a built-in active infrared illuminator.

B. Image processing and compression

1. The camera shall use a progressive scan CMOS image sensor.

2. The camera shall be fitted with a board-mounted automatic varifocal lens.

3. The camera shall have a wide dynamic range.

4. The camera shall have a high sensitivity.

5. The camera shall have an automatic electronic shutter.

6. The camera shall be capable of capturing and storing images using the following compression standards: H.264 MP (Main Profile) & M-JPEG.

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7. The camera shall offer a region of interest to zoom into a specific area of the full image.

8. The camera shall allow a region of interest to be sent in a separate stream so it is possible to view both an overview and a detail at the same time.

C. Night Vision (Infrared)

1. The camera shall have a LED high efficiency IR array for effective night vision.

2. The camera shall allow adjusting intensity of IR output to fit with the environment.

D. Audio

1. The camera shall offer G.711, AAC and L16 audio compression (live and recording).

2. The camera shall offer full duplex audio communication.

E. Network Video

1. The camera shall provide direct network connection.

2. The camera shall allow full camera control and configuration capabilities over the network.

3. The camera shall deliver video over a 10/100 Base-T, auto-sensing, half/full duplex, RJ45 Ethernet connection.

4. The camera shall comply with the IEEE 802.3af Power over Ethernet standard.

5. The camera shall conform to the ONVIF Profile S standard.

6. The camera shall support AutoMDIX.

F. Image Posting

1. The camera shall offer periodic JPEG image posting to an FTP server or a Dropbox account.

G. Access Security

1. The camera shall offer three levels of password protection.

2. The camera shall support 802.1x authentication using a RADIUS (Remote Authentication Dial In User Service) server.

3. The camera shall store a SSL certificate for use with HTTPS.

H. Recording and Storage Management

1. The camera shall support iSCSI devices to allow video stream to be recorded directly to an iSCSI RAID array.
2. The camera shall support iSCSI storage targets to enable the camera to function as a conventional DVR.
3. The camera shall have a microSD card slot.
4. The local storage feature shall be capable of storage for Automatic Network Replenishment (ANR).
5. Local Recording: Continuous recording, ring recording, alarm/events/schedule recording.

I. Alarm Handling Features:

1. The camera shall provide the capability on alarm to display up to a 31 character, programmable alarm message.
2. The camera shall provide email alarm messaging with optional JPEG posting.

J. Embedded Video Content Analysis

1. The camera shall be VCA enabled.
2. The camera shall be capable of processing and analyzing video within the camera itself, with no extra hardware required.
3. The camera shall be capable of detecting and sending alarms for abnormal events.
4. The camera shall allow users to set up to 10 separate profiles and switch profiles based on a day/night or holiday schedules.
5. The camera shall offer MOTION+ video motion analysis that uses an algorithm based on pixel change.
6. The MOTION+ feature shall include extended tamper detection capabilities.

K. Surveillance Software

1. The camera shall be accessible from a web browser, from Video Management System, or via third-party software.
2. The camera shall be accessible from the Security System mobile app.

L. Technical Specifications

| **Power** | |
|---|---|
| Input voltage | Power-over-Ethernet (48 VDC nominal); or 24 VAC / +12 VDC |
| PoE | IEEE 802.3af (802.3at Type 1)Power level: Class 3 |

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| Power | |
|---|---|
| Power consumption | PoE (12 W); 24 VAC (12.13 W); +12 VDC (13.2 W) |

| Sensor | |
|---|---|
| Sensor type | 1/2.9-inch CMOS |
| Total sensor pixels | 1936 (H) x 1097 (V); 2.12MP (approx.) |

| Video performance - Sensitivity | |
|---|---|
| Sensitivity - (3200K, reflectivity 89%, F1.3, 30IRE) | |
| Color | 0.07 lx |
| Mono | 0.05 lx |
| With IR | 0.0 lx |

| Video performance - Dynamic range | |
|---|---|
| Dynamic range | 76 dB |

| Video streaming | |
|---|---|
| Video compression | H.264 (MP); M-JPEG |
| Streaming | Multiple configurable streams in H.264 and M-JPEG, configurable frame rate and bandwidth. Regions of Interest (ROI) |
| Overall IP Delay | Min. 120 ms, Max. 340 ms |
| GOP structure | IP |
| Encoding interval | 1 to 30 [25] fps |
| Encoder regions | Up to 8 areas with encoder quality settings per area |

| Supported Video resolution (H x V) | |
|---|---|
| 1080p HD | 1920 X 1080 |
| 720p HD | 1280 x 720 |

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| Supported Video resolution (H x V) | |
|---|---|
| D1 4:3 (cropped) | 704 x 480 |
| SD upright (cropped) | 400 x 720 |
| 480p SD | Encoding: 704 x 480; Displayed: 854 x 480 |
| 432p SD | 768 x 432 |
| 288p SD | 512 x 288 |
| 240p SD | Encoding: 352 x 240;Displayed: 432 x 240 |
| 144p SD | 256 x 144 |

| Camera installation | |
|---|---|
| Base frame rate | 25/30 fps (PAL/NTSC for analog output) |
| Camera LED | Enable/disable |
| Analog output | Off, 4:3 letterbox, 4:3 crop, 16:9 |
| Positioning | Coordinates |
| Lens wizard | Zoom, Autofocus |

| Video functions - color | |
|---|---|
| Adjustable picture settings | Contrast, Saturation, Brightness |
| White Balance | Four automatic modes, manual mode and measure |

| Video functions - ALC | |
|---|---|
| Day/Night | Auto (adjustable), Color, Monochrome |
| Shutter | Automatic Electronic Shutter (AES);<br>Fixed shutter (1/25[30] to 1/15000) selectable; Default shutter |
| IR intensity | Adjustable |

| Video functions - enhance | |
|---|---|
| Sharpness | Sharpness enhancement level selectable |
| Backlight compensation | On/off |
| Contrast enhancement | On/off |
| Noise reduction | Intelligent Dynamic Noise Reduction with separate temporal and spatial adjustments |
| Intelligent defog | Intelligent Defog automatically adjusts parameters for best picture in foggy or misty scenes (switchable) |

| Video analysis | |
|---|---|
| Configurations | Silent VCA / Profile1/2 / Scheduled / Event triggered |
| Analysis type | MOTION+ |
| Tamper detection | Maskable |

| Additional functions | |
|---|---|
| Scene modes | Nine default modes, Scheduler |
| Privacy Masking | Eight independent areas, fully programmable |
| Video authentication | Off / Watermark / MD5 / SHA-1 / SHA-256 |
| Display stamping | Name; Logo; Time; Alarm message |
| Pixel counter | Selectable area |

| Local storage | |
|---|---|
| Internal RAM | 10 s pre-alarm recording |
| Memory card slot | Supports up to 32 GB microSDHC / 2 TB microSDXC card. (An SD card of Class 6 or higher is recommended for HD recording) |
| Recording | Continuous recording, ring recording. alarm/events/schedule recording |

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| Night vision | |
|---|---|
| Distance | 30 m (98 ft) |
| LED | 4 LED high efficiency array, 850 nm |
| IR intensity | Adjustable |

| Lens | |
|---|---|
| Lens type | Automatic Varifocal 2.7 to 12 mm, DC Iris F1.4 – 360, IR corrected |
| Lens mount | Board mounted |
| Horizontal field of view | 32° - 100° |
| Vertical field of view | 18° - 53° |

| Input/output connections | |
|---|---|
| Analog video output | CVBS, 1 Vpp, BNC connector, 75 Ohm<br>Selectable standard |
| Alarm input | Short or DC 5V activation |
| Alarm out | Input rating Maximum 0.5 A, 30 VAC / 40 VDC |
| Audio input | Flying leads; 10 kOhm typ. 0.707 Vrms |
| Audio output | Flying leads; 16 Ohm typ. 0.707 Vrms |
| Network connector | RJ45 |

| Audio streaming | |
|---|---|
| Standard | G.711, 8 kHz sampling rate<br>L16, 16 kHz sampling rate<br>AAC-LC, 48 kbps at 16 kHz sampling rate<br>AAC-LC, 80 kbps at 16 kHz sampling rate |
| Signal-to-Noise Ratio | >50 dB |
| Audio Streaming | Full-duplex / half duplex |

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| Software | |
|---|---|
| Unit discovery | IP Helper |
| Unit configuration | Via web browser or Configuration Manager |
| Firmware update | Remotely programmable |

| Network | |
|---|---|
| Protocols | IPv4, IPv6, UDP, TCP, HTTP, HTTPS, RTP/RTCP, IGMP V2/V3, ICMP, ICMPv6, RTSP, FTP, Telnet, ARP, DHCP, APIPA (Auto-IP, link local address), NTP (SNTP), SNMP (V1, MIB-II), 802.1x, DNS, DNSv6, DDNS (DynDNS.org, selfHOST.de, no-ip.com), SMTP, iSCSI, UPnP (SSDP), DiffServ (QoS), LLDP, SOAP, Dropbox, CHAP, digest authentication |
| Encryption | TLS 1.0, SSL, DES, 3DES |
| Ethernet | 10/100 Base-T, auto-sensing, half/full duplex |
| Connectivity | Auto-MDIX |
| Interoperability | ONVIF Profile S; GB/T 28181 |

| Mechanical | |
|---|---|
| 3-axis adjustment (pan/tilt/rotation) | 360º / 90º / 360º |
| Dimensions (H x W x D) | 271 x 90 x 90 mm (10.7 x 3.5 x 3.5 in) |
| Weight | 1.3 kg (2.9 lb) |
| Color | RAL 9006 |

| Environmental | |
|---|---|
| Operating temperature | -30 ºC to +60 ºC (-22 ºF to +148 ºF) for continuous operation;<br><br>-34 ºC to +74 ºC (-30 ºF to +165 ºF) according to NEMA TS 2-2003 (R2008), para 2.1.5.1 using fig. 2.1 test profile |
| Storage temperature | -30 ºC to +70 ºC (-22 ºF to +158 ºF) |
| Humidity | 20% to 90% relative humidity (non condensing) |

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## 4.03 Outdoor Network/IP IR PTZ Dome Camera 1080P Full HD

I. General Characteristics:

A. The camera shall provide a 1/2.8-in. type progressive scan CMOS sensor with the following:

- 1984 x 1225 (2.43 MP) effective picture elements.
- Sensitivity to below 0.11 lux (day/color mode and night/black and white mode).

Sensitivity down to 0
lux with infrared (IR) enabled.

1. The camera shall offer 1080p resolution for capturing fast motion. The camera shall have an integrated IR illuminator for capturing clear video during night mode or scenes with no artificial illumination.
2. Camera shall have 4 illuminators that adjust IR power/intensity automatically according to zoom and focal length to ensure uniform illumination of scenes.
3. The camera shall support IR threshold, based on zoom value, where the illuminators will not be ON and functioning.
4. The camera shall provide direct network connection using H.264 and M-JPEG compression and bandwidth throttling to manage bandwidth and storage requirements efficiently while delivering outstanding image quality.
5. The camera shall support the following dual, redundant power options:

a. Options:

1) 24 VAC

2) PoE+ (IEEE 802.3at, class 4)

b. The camera shall default to use power from the 24 VAC power supply, if connected.

c. The camera shall switch to PoE+ power supply if power from the 24 VAC power supply is lost with no interruption to camera operation.

7. The camera shall offer a dynamic range of 76dB (DWDR) for clear images in extreme high-contrast environments.
8. The camera shall offer 256 user-defined pre-positions with 20-character titles.
9. The camera shall offer three configurable, pre-programmed user modes.
10. The camera shall offer bi-directional audio.
11. The camera shall be able to be mounted to a wall, mounted to a surface, or mounted to a pipe.

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12. The camera shall offer IP66 environmental protection for pendant housing

13. The camera shall support the multiple languages such as Dutch, English, French, German, Italian, Japanese, Russian, Spanish, Simplified Chinese, Polish, and Portuguese.

B. Imaging

1. The camera shall provide a 1/2.8-in. type progressive scan CMOS sensor.

2. The camera shall offer an effective number of pixels of 1984 x 1225 (2.43 megapixels).

3. The camera shall offer a 16:9 aspect ratio.

4. The camera shall offer a 12x optical zoom lens (5.1 to 61.2 mm).

5. The camera shall have 4.6° to 51.3° field of view.

6. The camera shall produce a color image with a minimum scene illumination of 0.20 lux and a monochrome image, when in the night mode, with a minimum illumination of 0.04 lux at 50 IRE.

7. The camera shall offer automatic focus control with manual override.

8. The camera shall offer automatic iris control.

9. The camera shall offer a dynamic range of 76dB (DWDR).The camera shall offer the following White Balance modes: Standard Auto, Sodium Vapor Auto, Basic Auto, Manual, Hold, Dominant Color Auto. The mode Sodium Vapor Auto automatically compensates for light from a sodium vapor lamp to restore objects to their true color.

10. The camera shall offer an intelligent defog image feature that assists the camera in registering a usable image through the heaviest fog.

11. The camera shall offer a Signal-to-noise ratio (SNR) of >50 dB.

12. The camera shall offer the following day/night modes: Mechanical switchable IR filter (Auto/On/off) and Monochrome.

13. The camera shall offer Backlight Compensation.

C. System Features

1. The camera shall be compatible with the Video Client and Video Management System.

2. The camera shall provide one (1) audio mono line in and one (1) audio mono line out.

D. PTZ Features

1. The camera shall provide the following modes for variable pan/tilt speeds:

   a. Turbo Mode (manual control):

      1) Pan: 1°/s to 240°/s

      2) Tilt: 1°/s to 120°/s

   b. Normal Mode:

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1) Pan: 1°/s to 120°/s

2) Tilt: 1°/s to 120°/s

2. The camera shall provide a preposition speed of:

   a. Pan: 1°/s to 240°/s

   b. Tilt: 1°/s to 160°/s

3. The camera shall provide a pan range of 360° continuous.

4. The camera shall provide a tilt angle of0° above the horizon for pendant housings.

5. The camera shall divide the cameras 360º rotation into 16 independent sectors with 20-character titles per sector. Any or all of the 16 sectors can be blanked from the operator's view.

6. The camera shall offer the ability to define 24 masks with up to 8masks per scene that prohibit areas of the field of view from being seen even if the camera is panned, tilted, or zoomed.

7. The camera shall store up to 256 preset scenes with each preset programmable for 20 character titles.

8. The camera shall support the following tour modes:

   a. One (1) preset tour capable of 64 sequential pre-positions and a configurable dwell time between positions.

   b. Two (2) separate tours of an operator's keyboard movements consisting of pan, tilt and zoom activities. The recorded tours can be continuously played back.

   c. One (1) 360° AutoPan mode.

   d. One (1) AutoPan mode between limits.

The camera shall execute one of the following programmable options when an operator stops manual control of the camera, and a programmed period of time is allowed to expire: return to a stored preset number, return to the automated tour previously executed, and do nothing.

E. Pre-programmed Modes

1. The camera shall offer three (3) pre-programmed but configurable user modes.
2. The pre-programmed modes shall be optimized with the best settings for the following environments:
   a. Indoor: For general day-to-night changes without sunhighlights and street lighting
   b. Outdoor: For general day-to-night changes with sunhighlights and street lighting
   c. Vibrant: For enhanced contrast, sharpness, and saturation
3. The camera shall allow users to customize these modes for the specific requirements of the camera site.

F. Illuminator

1. The IR illuminator shall be part of the moving platform which can Pan/Tilt along with the camera head.
2. The illuminator shall detect objects up to 180 m (590 ft).
3. The IR illuminator shall be synchronized with the camera so that if IR is turned on manually, the camera shall switch to B/W mode.
4. The IR illuminator shall have variable illumination so that IR light is distributed evenly in the field of view to avoid dark spots or over-illuminated scenes.
5. The IR illuminator shall be capable of being configured on a per-zone basis to ensure a single dominant illumination source in a specific scene.
6. The IR illuminator shall comply to IEC-62471 (Eye Safety for IR LEDs).

G. Recording and Storage Management

1. The camera shall support iSCSI devices to allow video stream to be recorded directly to an iSCSI RAID array.
2. The camera shall support iSCSI storage targets.
3. The camera shall have an SD card slot that uses a microSDHC or microSDXC card for local storage (up to 2 TB).
4. The camera shall be compatible with the Video Recording Manager (VRM) to control and manage video recording.

H. HD Characteristics

1. The camera shall support H.264 video compression.
2. The camera shall generate HD 720p or 1080p resolution (depending on model) using H.264 compression (ISO/IEC 14496-10).
3. The camera shall generate multiple simultaneous configurable HD video streams.
4. The camera shall allow simultaneous streaming of individual HD streams, and allow a choice of HD resolution in combination with SD resolutions.

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I. IP Connectivity

1. The camera shall allow full camera control and configuration capabilities via a TCP/IP network.

2. The camera shall support the following dual, redundant power options:

   a. Options:

      1) 24 VAC

      2) PoE+ (IEEE 802.3at, class 4)

   b. The camera shall default to use power from the 24 VAC power supply, if connected.

   c. The camera shall switch to PoE+ power supply if power from the 24 VAC power supply is lost with no interruption to camera operation.

3. The camera shall be capable of capturing and storing images using H.264 compression at HD 720p or 1080p resolution.

4. The camera shall deliver 720p or 1080p video, at rates up to 30 images per second via TCP/IP over Cat5/Cat6 UTP cable.

5. The camera shall support iSCSI devices to allow the network-enabled camera to stream video directly to an iSCSI RAID array.

6. The camera shall conform to the ONVIF Profile S specifications.

7. The camera shall offer Quality of Service (QoS) configuration options.

8. The camera shall support the IPv6 internet-layer protocol for packet switched internetworking across multiple IP networks.

J. Motion Detection

1. The camera shall include an algorithm for detecting movement on presets or for alarm signalling.

2. The camera shall be able to interface to an external alarm source using the built-in alarm I/O ports.

K. Access Security

1. The camera shall offer three levels of password protection.

2. The camera shall support 802.1x authentication using a RADIUS (Remote Authentication Dial In User Service) server.

3. The camera shall store a SSL certificate for use with HTTPS.

4. [The camera shall be capable of being independently AES encrypted with 128-bit keys.]

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L. Installation Requirements

1. The camera shall be capable of operating in an outdoor environment within the following temperature range:
   a. -40 °C to +60 °C (-40 °F to 140 °F)
2. The camera shall accept power, transmit video, and accept control via TCP/IP connection.
3. The camera shall support the following dual, redundant power options:
   a. Options:
      1) 24 VAC
      2) PoE+ (IEEE 802.3at, class 4)
   b. The camera shall default to use power from the 24 VAC power supply, if connected.
   c. The camera shall switch to PoE+ power supply if power from the 24 VAC power supply is lost with no interruption to camera operation.
4. The camera shall provide a multi-language on-screen display.

M. Housing Specifications and Options

1. The camera shall be offered in an outdoor pendant aluminum housing.
2. The camera shall provide built-in surge protection for power, data, and video and alarm inputs.
3. The outdoor pendant housing shall:
   a. Use a hook, in place of a tether, to make installation easier and safer.
   b. Allow the camera to view 0º above the horizon.
   c. Conform to the IP66 standard.
   d. Provide an operating temperature of -40 °C to +60 °C (-40 °F to 140 °F).
   e. Be powder coated in white (RAL 9003).
   f. Include a sunshield of outdoor grade plastic.

N. Mechanical

1. PanRange: 0 to 360° continuous
2. Tilt Angle: 0° above horizon
3. Pre-position Speed:
   a. Pan: 240°/s
   b. Tilt: 160°/s

4. Pan/Tilt Modes:
    a. Turbo Mode:
        1) Pan: 1°/s to 240°/s
        2) Tilt: 1°/s to 120°/s
    b. Normal Mode:
        1) Pan: 1°/s to 120°/s
        2) Tilt: 1°/s to 120°/s
5. Preset Accuracy: ± 0.2° typical

O. Electrical

1. Input Voltage:
    a. 24 VAC, 50/60 Hz (class 2)
    b. PoE+ (IEEE 802.3at, class 4)]
2. Power Consumption (typical):
    a. 24 VAC: 23 W
    b. PoE+: 25 W

P. Network

1. Communications Protocols: Standard IP protocol, including ONVIF and SNMP v1
2. Video Compression: H.264 (ISO/IEC 14496-10), M-JPEG, JPEG
3. Streaming: Two (2) individually configurable streams:
    a. Stream 1
        1) H.264 MP SD
        2) H.264 MP 720p fixed
        3) H.264 MP 1080p fixed [for 1080p models only]
    b. Stream 2:
        1) Options with ¯H.264 MP 1080p fixed‖ selected for Stream 1:
            a) Copy Stream 1
            b) H.264 MP SD
            c) H.264 MP 720p8/10 Fixed
            d) H.264 MP 1080p4/5 Fixed

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e) H.264 MP 400x720 upright (cropped)

f) H.264 MP D1 4:3 (cropped)

2) Options with ¯H.264 MP 720p fixed‖ selected for Stream 1:

a) H.264 MP SD

b) H.264 MP 720p fixed

c) H.264 MP 400x720upright (cropped)

d) H.264 MP D1 4:3 (cropped)

e) H.264 MP 1280x960 (cropped)

3) Option with ¯H.264 MP SD‖ selected forStream 1:

a) H.264 MP SD

4. Resolution (H x V):
   a. 1080p HD: 1920x1080
   b. 720p HD: 1280 x 720
   c. 432p SD: 768 x 432
   d. 288p SD: 512 x 288
   e. 144p SD: 256 x 144
5. Protocols: IPv4, IPv6, UDP, TCP, HTTP, HTTPS, RTP/RTCP, IGMP V2/V3, ICMP, ICMPv6, RTSP, FTP, Telnet, ARP, DHCP, SNTP, SNMP (v1, MIB-II), 802.1x, DNS, DNSv6, DDNS (DynDNS.org, selftHOST.de, no-ip.com), SMTP, iSCSI, UPnP (SSDP), DiffServ (QoS), LLDP, SOAP, Dropbox, CHAP, digest authentication
6. Ethernet:10-Base T/100 Base-TX, auto-sensing, half/full duplex, RJ45
7. Encryption: TLS 1.0, SSL, DES, 3DES, AES
8. GOP Structure: IP, IBP, IBBP
9. Data Rate: 9.6 kbps to 6 Mbps (per stream)
10. Overall IP Delay:240ms
11. Audio
    a. Standard:
       1) G.711, 8 kHz sampling rate
       2) L16, 16 kHz sampling rate
       3) AAC, 16 kHz sampling rate
    b. Signal-to-Noise Ratio: >50 dB

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c. Audio Streaming: Bidirectional (full-duplex)

Q. Local Storage

1. Memory Card Slot: microSDHC or microSDXC memory card (maximum2TB)
2. Recording: Continuous recording of video and audio, alarm/events/schedule recording

R. Miscellaneous

1. Sectors/Titling: 16 independent sectors with 20-character titles/sector
2. Masking: 24, individually configurable
3. Pre-positions: 256, each with 20-character titles
4. Guard Tours: Two (2) types of tours:
   a. Recorded tours – two (2), total duration of 15 minutes
   b. Preset tour – one (1), consisting of upto 64 scenes, consecutively
5. Supported Languages: Chinese, Dutch, English, German, French, Italian, Japanese, Portuguese, Polish, Russian, and Spanish

S. User Connections:

1. Power
   a. RJ-45 100 Base-TX Ethernet PoE+ (IEEE 802.3at, class 4 standard)
   b. 24 VAC, 50/60 Hz
2. Video and Control: RJ-45 10/100 Base-TX Ethernet
3. Alarm Inputs (2): 2 supervised / non-supervised; programmable for ―normally open‖ or ―normally closed‖
4. Alarm Outputs (1): 1 dry contact relay
5. Audio:
   a. Signal Line In: 12 kOhm typical, 1 Vrms max
   b. Signal Line Out: 1 Vrms at 1.5 kOhm, typical

T. Environmental

1. Ingress Protection Rating/Standard: IP66
2. Operating Temperature:
   a. -40°C to +60 °C (-40 °F to 140 °F)
3. Storage Temperature:
   a. -40 °C to +60 °C (-40 °F to 140 °F)
4. Humidity:
   a. > 90% RH

U. Construction

1. Product Weight:4kg (8.8 lb)
2. Construction Material:
   a. Housing: Cast aluminum
   b. Sunshield: Outdoor grade plastic
3. Standard Color: White (RAL9003)

## II. Camera with Remote Control Mechanism

This type of camera shall either be fixed type or automatic pan/tilt type, complete with remote control box for remote control from the control console for the following operations:

1. Pan : Auto-Manual mode, left and right
2. Tilt : Auto-Manual mode, up and down (for all camera with zooming mechanism)
3. Zoom : Short and long
4. Focus : Near and far

Automatic light compensation device shall be provided for all cameras with remote control mechanism.

## III. Video Amplifier (if applicable)

1. Video amplifier shall be provided if the video transmission signal is degraded by the coaxial cable. The Contractor shall be responsible to ensure of a good video signal transmission in order to achieve a clear picture in the control console's monitor.

## IV. Camera Power Supply Unit

The power supply unit shall be rated at 10 amperes with 230 VAC, 50Hz Input and Output. It shall be capable of supplying power to 16 cameras having 16 individual outputs with separate power circuit breaker and indication LED. The body shall be NEMA 1 class steel enclosure anti-rust treated and powder coated. It shall be UL certified.

## V. CAMERA HOUSING

A. Indoor Camera Housing

1. All indoor cameras, including those for lift cars, shall be equipped with indoor housings to provide protection for the cameras and to prevent tampering. This shall be done by equipping necessary tamper alarm circuit which shall be connected back to the respective control console for warning if being tampered. Tamper alarm switch and signal shall be provided for each camera. Such camera signal shall be automatically displayed onto the monitor for immediate identification.

2. The construction of the housing shall be one piece extruded aluminium housing not less than 1.2mm thick with key locked.

3. Mounting bracket shall be provided for each camera and housing. Mounting brackets shall be so manufactured to provide rigid support and to resist tampering and environmental conditions. To facilitate durability, mounting brackets shall be constructed of steel and aluminium, zinc plated and capable of supporting a minimum weight of 20 kg.

4. Proper cable entry by means of G.I. flexible conduits into the cameras housing shall be provided. Samples shall be submitted for approval.

5. For housings inside ceiling void, maintenance access shall be co-ordinated by the Contractor with Building work.

B. Outdoor Camera Housing

1. The housings shall be water-tight of an insulation rating IP65, and be manufactured to protect the cameras from dust, water, moisture and temperature outside the ambient limits of the cameras.

2. The housings shall be constructed in two pieces to suit the camera; which are the mounting base and removable housing cover. The mounting base shall be of plated steel. The cover shall be of brushed, anodised aluminium to eliminate the need for sun shroud. Tamper alarm circuit shall be provided similarly to the indoor housing.

3. The following shall be provided for each housing:

   a. Filtered Blower System – thermostatically controlled to operate in all housing.

   b. Close Circuit Warning System – tamper alarm circuit to be reported to the control console.

4. Proper cable entry by means of G.I. flexible conduits into the cameras housing shall be provided. Samples shall be submitted for approval.

C. Wall Mount

The wall mount shall be a light-duty adjustable indoor/outdoor unit. It shall be of die-cast aluminum construction. It shall have a load rating of 25 lb (11.4 kg). Height and width shall not exceed 5.4 in. (13.6 cm) and 2.9 in. (7.4 cm). Respectively depth shall not exceed 11.0 inches (27.9 cm). Weight shall not exceed 1.5 lb (0.7 kg). The head shall be manually adjustable over a pan range of 360° and a tilt range of ± 75°.

## VI. CABLING

A. The coaxial cables used in the CCTV System shall be 75 ohm impedance copper cable specially manufactured for transmitting video signals. The cable shall consist of a single wire

or stranded conductor of 1/1.12mm minimum, insulated with cellular, a branded copper screen forming the second conductor with a PVC sheath to protect the screen. The cable shall comply to BS2316 Part 3.

B. All internal cabling is to be done using RG-59/U (20 AWG) and RG-6/U (18 AWG) cable with the following characteristics:

a) Dielectric insulating Materials - Foam Polyethylene

b) Braid or shield - Pure Copper

c) Center core cable - Standard

C. The coaxial cable shall be protected against mechanical damage, electrical interference causing malfunction, and free from excessive attenuation of signal strength. No joint shall be allowed in between termination boxes.

D. All multicore cables for control and monitoring purpose shall conform to BS 3573.

E. For those cables running outdoor and inside PVC pipes, special coaxial cable and multicore cables of armoured type shall be employed to prevent any mechanical damage that may arise.

F. All external cabling is to be done using RG-11/U (16 AWG) cable with the following characteristics:

a) Dielectric insulating Materials - Solid Polyethylene

b) Braid or shield Material - Pure Copper

c) Center core cable - Standard

G. Control and power cables shall be terminated by means of approved type terminations. Positive connectors may be used with prior approval from the Engineer. Video signal shall be terminated with coaxial plug connectors of acceptable type.

H. The Contractor shall co-ordinate with the Lift installation on the specification of the co-axial cable for the lift shaft. Selected cable shall be suitable and compatible to ensure a clear and optimum image from the CCTV system.

I. Lightning arrestors shall be provided for the circuit serving any outdoor cameras prior to connection back to the system.

The cables are to be run in steel conduit and class D PVC conduit surface mounted and buried in below ground as required by the environment.

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# CATV SYSTEM

# CATV SYSTEM

## 1. GENERAL

### 1.01 DESCRIPTION

The contractor shall supply and install a complete IP paging system as described herein and as shown on the plans to be wired, connected and left in good operating condition. An IPTV service commonly occurs between an UE terminal and an IPTV server. The PQoS-aware UE terminal may be an IMS-compatible smart phone connected to the UMTS network and requesting an IPTV session (either in Live or VOD). The IPTV server will be located in the MSRF, with IMS functionalities, and it will be able to deliver VOD or Live IPTV services. IPTV service between UE terminal and MSRF IPTV server.

### 1.02 CODEC

IPTV supports the MPEG-2, MPEG-4, H.263 and H.264; the server will support these standards, and 15-30 frames per second should be supported as temporal resolution. Spatial resolution will be adapted with respect to the user‘s terminal resolution. Typical mobile phones can handle QCIF video (176x144) and PDAs usually have a resolution of 320x240.

### 1.03 TRANSPORT PROTOCOL

The system will rely on MPEG transport stream, RTP and RTSP and they will be the protocols used.

### 1.04 SIGNALING PROTOCOL

IPTV uses SIP as the signaling protocol. Additionally to SIP the SDP protocol is used to describe the multimedia session between the server and the client. SDP information is carried inside SIP messages as message payload.

### 1.05 QoS

IPTV and VOD which are low loss applications require class 4 (According to ITU-T Y.1541). This means that they require:
> an IP packet Transfer Delay (IPTD) of 1s.
> an IP packet Delay Variation (IPDV) of unspecified value. The performance with respect to IPDV may, at times, be arbitrarily poor.
> an IP packet Loss Ratio (IPLR) of 1*10-3 .
> an IP packet Error Ratio (IPER) of 1*10-4 .

### 1.06 USER TERMINALS

User access terminal should be capable of negotiating upon line conditions to utilize the maximum available bandwidth for video transmission. User terminals should be PQoS aware.

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# BUILDING MANAGEMENT SYSTEM

**Building Management System**
**[Refer HVAC discipline for BMS specifications]**

# STANDBY DIESEL GENSET SYSTEM

# STANDBY DIESEL GENSET SYSTEM

## 1. GENERAL

### 1.01 WORK DESCRIPTION

A. This section describes the engineering, supply, delivery to site, hoisting into position, install, test and commission the standby generating system together with the necessary controls and switchboards as specified and indicated in the Drawings. Protection circuits, control wiring system and interlock circuits not specified or indicated in the Drawings, but deemed necessary for the safe operation of the generating system shall be provided to complete the system. The standby generator set shall provide secondary supplies to all ‗essential' services such as hose reel, wet riser, sprinkler pump, fire lifts, ventilation fans, emergency lighting, etc., in the event of mains failure.

B. All the equipment quoted shall be manufactured to accommodate in the room or open space provided per the tender drawing. The standby generating system shall comply with the requirements of Local Authority.

### 1.02 SUBMISSION

A. All technical submissions shall be approved by the Engineer prior to the respective stages of construction.
B. As a minimum requirement, the submission shall include the following:
   1. Equipment submission with manufacturer's data.
   2. Shop drawing showing the coordinated installation detail and control block diagram.
   3. Builder's works requirement.
   4. Detail water cooling circulation drawing complete with cooling tower, pump sizing calculation endorsed by the Contractor and Manufacturer.

### 1.03 STANDARDS

A. The complete system and installation shall be engineered and constructed in accordance with the latest revision of the standards and the appropriate BS/IEC as specified in this specification.

B. The complete system and installation shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

C. In the adoption of standards and requirements, the Contractor shall take the following precedence:

1. Engineer's decision;
2. Local codes of practice;
3. Drawings;
4. Specification;
5. International standards and requirements

## 2. PRODUCT

### 2.01 DIESEL ENGINE

A. The diesel engine shall be of the 4 stroke, multi-cylinder direct injection, compression ignition type operating at a speed of 1500 rpm with vertical in-line or V form cylinders, and as far as possible be silent, vibration free while in operation and comply with BS 5514.

B. The engine shall be complete with water cooled body jacket, water cooled engine, fan, lubricating oil pump, lubrication oil pressure gauge, tachometer, digital or electronic type governor, integrated hours-run recorder, over speed trip and all other necessary auxiliaries.

C. The brake horse power of the engine with all attached accessories as specified shall not be less than that which is required by the full load rating of the alternator taking into consideration losses, plus a reserve factor of at least 10%.

D. Starting

1. Starting system of the standby generator shall be of a heavy-duty electric motor complete with a 24 V.D.C. heavy-duty battery of at least 300 AH. The electric motor shall be capable of cranking the engine to achieve the rated speed in less than 10 seconds from the initiation of the starting process. The electric start battery shall be of adequate capacity for 10 successive starts. Time delay relays shall be incorporated to provide a rest period of 1-5 seconds (adjustable) before each successive start and a time lag period of 19-100 seconds (adjustable) before the system lock out due to failure of the 5$^{th}$ start to crank up the engine.

2. The generator set shall be provided with a micro-processor based control system which is manufactured to provide automatic starting, monitoring, and control functions for the generator set. Interface to BMS system according to point schedule on drawings shall be provided.

3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

E. Speed Regulation

1. The governor shall be capable of regulating the speed of the engine within the limits approximately 10% of the rated speed within 4 seconds due to a sudden application or removal of a full load. The steady load speed shall vary within the limits of approximately 1% of the rated speed.

F. Cooling

1. The engine cooling system shall be of a closed circuit water recalculating system to cool the engine as well as the body to minimize heat radiated into the generator room. The cooling circuit will exchange heat through a heat exchanger capable to remove the heat generated under continuous full load operation. Condenser water from cooling tower will be provided by Contractor_s mechanical work to exchange the heat to external of the building. The cooling system shall include the heat exchanger, fan, pump and all ducting, acoustic attenuation and support brackets for mounting of the heat exchanger.

G. Lubricator

1. The lubricating system shall be by a positive displacement oil pump providing a positive force feed to all lubricating points.
2. Good quality lubricating oil filters with replacement elements shall be provided.

H. Exhaust System

1. Adequate sized piping and fittings shall be installed to carry the engine exhaust discharge into the atmosphere as indicated in the drawings.

2. Mufflers shall be installed to reduce the engine exhaust noise to a maximum of 5 dBA above ambient noise level at nearest area accessible to the public within 3m from Generator Room and at least 2m above floor level. Flexible connection shall be provided between the engine and the fixed

piping. All fittings shall be wrapped in an approved calcium silicate heat insulation material of 40mm thick and shall be rigidly bonded and supported.

## 2.02 FUEL PIPING AND FUEL TANK INSTALLATION

A. The complete system shall include engineering, supply, installation, testing and commissioning the tanks, pumps, piping, valves and control system.

## 2.03 INSTRUMENTS

A. An instrument panel mounted on the engine shall be provided and shall comprise the following flush-mounted instruments and gauges:

1. Cooling water inlet temperature
2. Cooling water outlet temperature
3. Cooling water inlet temperature to lubricating oil cooler
4. Lubricating oil inlet temperature
5. Lubricating oil outlet temperature
6. Lubricating oil pressure gauge
7. Tachometer, positive driven
8. Elapsed hour counter.

## 2.04 PROTECTION DEVICES

A. Warning indication and automatic shut-down shall be provided for the following:

1. Low oil pressure (alarm)
2. Low oil pressure (shutdown)
3. Oil pressure sender failure (alarm)
4. Low coolant temperature (alarm)
5. High coolant temperature (alarm)
6. High coolant temperature (shutdown)
7. Engine temperature sender failure (alarm)
8. Low coolant level (alarm or shutdown – selectable)
9. Fail to crank (shutdown)
10. Overcrank (shutdown)
11. Overspeed (shutdown)
12. Low DC voltage (alarm)
13. High DC voltage (alarm)
14. Weak battery (alarm)
15. Low fuel-day tank (alarm)
16. High AC voltage (shutdown)
17. Low AC voltage (shutdown)
18. Under frequency (shutdown)
19. Over current (warning)
20. Over current (shutdown)
21. Short circuit (shutdown)
22. Ground fault (alarm)
23. Overload (alarm)
24. Emergency stop (shutdown)

B. Failure warning lights and an alarm buzzer shall be installed at the control panel and shall have indication of they type of fault. Manual reset facilities shall be incorporated to restore the operation to normal.

C. The starting circuit shall be disconnected in the event of any of the above shutdowns.

## 2.05 ALTERNATOR

A. The alternator shall be foot-mounted drip proof, self-ventilated and screen-protected and directly coupled on to the diesel engine by flexible driving discs.

B. The full load output voltage shall be 400 volts, 3 phase, 4 wire, 50 Hz at 0.8 power factor with neutral solidly earth with the frequency maintained at 0.5 Hertz at all time under any load condition including transient overload due to motor starting etc. The alternator shall be manufactured and tested in accordance with BS 2613, to suit local conditions.

C. The rotor shall consist of the main alternator field poles the brushless exciter and its rectifier module, all bolted on a common alternator shaft. The rotor shall be mechanically and electrically balance up to 135% of the rated speed. The insulation of the alternator shall be non-hygroscopic, Class ¯H‖ on the exciter, Class ¯H‖ on the stator and Class H on the rotating pole pieces.

D. The rectifier module of the exciter shall be impregnated with epoxy resin and shall be capable of withstanding without damage or deterioration of the thermal, centrifugal and other stresses that is experience during normal or short circuit conditions. Rectifiers shall be of silicon type.

E. The voltage build up shall be of self-excitation using the residual voltage of the alternator through a solid-state voltage regulator. The voltage regulator shall be capable of maintaining the voltage regulation to ± 1% independent of power factor, heating and 5% of speed variation. The voltage output of the alternator shall also be capable of manual adjustable to ± 5% of the rated voltage.

F. The response of the voltage regulator shall be less than 10 millisecond. The voltage dip shall not exceed 15% when a rated continuous load is supplied to the unloaded alternator and the correction time shall not exceed 200 millisecond. When the rated load is withdrawn, the voltage overshoot shall not exceed 20%.

G. The automatic voltage regulator and the exciter shall be manufactured to withstand 50% overload at a constant terminal voltage.

H. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of motor current for not more than 10 seconds.

## 2.06 GENERATOR CONTROL PANEL

A. The generator control panel shall be floor-mounted, and shall have all necessary instruments and accessories for operation and control of the generating set. On sensing the utility mains voltage dip of 40% of the rated voltage, the control panel shall send a signal to start the generator. After 5 successive start and if the diesel generator is not started up, the alarm signal shall be activated.

B. The generator control panel shall consist of all Auto-transfer switch, circuit breakers, protective relays if applicable and accessories required to control the generator operation and shall include but not limited to the following:

1. Voltmeters
2. Frequency meter
3. Power factor meter
4. Ammeters
5. Kilowatt meter with maximum demand indicator
6. Kilowatt hour meter
7. Hour run meter
8. Start-stop and automatic mains monitoring system
9. Emergency off push button

10. Manual speed adjusting switch, reset switches for overload, alarm muting, etc.
11. Fully automatic trickle battery charger with battery voltmeter
12. Indicating lamps for ‗Mains Available', ‗Mains on Load', ‗Standby Available', ‗Standby on Load', ‗Alarm', ‗Mains Fail', etc.
13. Audio and visual (flasher) alarm system.

C. The start-stop and automatic mains monitoring system shall be equipped with the following:

1. Duty selector switch for ‗off-automatic-test-manual' operation
2. Manual start-stop push button switch
3. Manual alternator circuit breaker ‗On-Off' switch
4. Cancel alarm switch
5. Reset switch
6. Indicating lamps

## 2.07 BUILDING MANAGEMENT SYSTEM CONNECTION

A. Voltage free auxiliary contacts and high level interface shall be provided including transducers, current transformer, software, etc. required by Contractor's BMS work. The detail shall be subject to co-ordination. All cost for interfacing requirement shall be included in the Contract.

## 2.08 ACOUSTIC TREATMENT

A. The Contractor shall submit calculations, engineering, supply and install the acoustic treatment for the Generator Room to ensure that the noise level is not more than 75 dBA and measured at 1.0m externally away from the doors and louvers of the Generator Room.

# 3. EXECUTIVE

## 3.01 TESTING AND COMMISSIONING

A. All the necessary comprehensive tests shall be performed to the approval and satisfaction of the Engineer at the completion of installation. Before the commencement of acceptance testing, the installation shall be in a state of practical completion and shall have completed all of the preliminary testing and adjusted the equipment to its proper running order.

B. A full seven (7) days' notice of his readiness for carrying out acceptance tests shall be given to the Engineer.

C. Prior to the date of giving such notice a complete details schedule of the tests to be carried out shall be submitted to the Engineer for his approval and alternations and additions to the schedule are made may required.

D. Notwithstanding his approval of the testing schedule the Engineer may at any time before or during the testing period direct further tests to be carried out that he considers necessary.

E. On receiving notice of the readiness for acceptance testing the Engineer shall set aside and designated a period for the carrying out of acceptance tests. During this period no modification, adjustments or other work on the installation shall be done without the express permission of the Engineer in each case.

F. Should there be any contravention of this requirement the Engineer may reject the results of all tests completed and order a commencement of testing programme.

G. A detailed day-to-day program of testing shall be prepared and all measures necessary to ensure that testing proceeds as much as possible in accordance with this programme shall also be taken.

H. Any variation to the programme during the testing period shall be at the discretion of the Engineer.

I. Upon completion of all above tests, four (4) sets of the test results shall be submitted for the Engineer's approval. All test reports submitted shall be endorsed by all parties witnessing the test including the contractor's and manufacturer's Qualified Personnel.

J. No acceptance tests shall be carried out except in the presence of the Engineer or their authorised representatives appointed for the purpose.

K. The Contractor shall provide at his own cost all materials, including electric power, instrument test set, fuel, lubricants and other consumable, Load Bank required for the tests and adjustments of the equipment and for carrying out the acceptance tests and any re-tests that may be necessitated by failure of the installation or by any other causes within his control.

L. The Contractor shall ensure that the fuel supplied for use in acceptance tests is part of a batch for which certified test data is available. Two copies of the test certificate shall be supplied to the Engineer prior to the commencement of tests.

M. During the testing period the Contractor shall appoint a qualified personal to carry out the checking and testing the testing instrument (equipment which are to be used for the test) including accurately calibrated test equipment for checking the accuracy of gauges and instruments forming part of or supplied with the installation.

N. Prior to commencement of testing a detailed list of the equipment shall be submitted to the Engineer for his approval and no item on the list shall be removed from the site without his consent until the completion of testing.

## 3.02 FACTORY TEST

A. Tests proving the satisfactory performance of all safety controls shall be carried out. These shall include the over speed and oil pressure failure cutouts, and such other safety devices and automatic alarms as are required to satisfy this Specification.

B. Governor trials shall be carried out as laid down in BS 5514. IF the Governor performance does not come within the prescribed limits, the Contractor shall make the necessary adjustments and repeat the Governor trial until satisfactory results is obtained.

C. The preliminary electrical tests required to be carried out by the Contractor shall include the following:

1. Insulation resistance:
   Stator, rotor and exciter windings to earth
   Stator – between windings

2. Check of efficiency of radio interference suppression equipment control panels shall be carried out concurrently with the preliminary engine and alternator tests.

3. The Contractor shall include the cost for the requirement for witness at manufacturer for Factory Acceptance Test (FAT), the Engineer and Employer representative – 2 persons 3 days (excluding transport time) for tests at USA embassy rate.

## 3.03 PERFORMANCE TESTS

The schedule of tests to be performed in the Factory Acceptance Test shall include the following:

A. On each of three separate days and before any other operation of the diesel-alternator on that day three successful manual start-up operations to be accomplished.

B. Three separate manual start-up operations each within one minute of the diesel-alternator being shut down after running continuously for not less than one hour and attaining normal engine running temperatures.

C. Three separate automatic start-up operations with simulation of ―mains failure‖. In all or any of these rests the diesel-alternator may be out on load by the automatic closing of the emergency power supply circuit breaker.

D. Three separate automatic shutdown operations, each initiated by mechanical simulation of a ―low pressure‖ condition.

E. Three separate automatic shutdown operations, each initiated by manual instigation of an ―over-speed‖ condition.

F. Three separate abortive start-up operations, each inducing ―failure to start‖ shut-down.

G. The load tests shall be carried out as follows:

| | | |
|---|---|---|
| 1. | 25% of full load at 1.0 pf | For half hour |
| 2. | 50% of full load at 1.0 pf | For one hour |
| 3. | 100% of full load t 1.0 pf | For two hours |
| 4. | 110% of full load at 1.0 of | For one hour |

At the completion of the test, readings shall be taken of Voltage, Frequency, Current, Temperature, Vibration and the following:

Insulation resistance – rotor, stator, exciter – to earth;
Insulation resistance – between stator windings;
Alternator rotor and exciter armature temperature

After the load run, all inspection doors shall be removed from the engine, the running gear examined and all nuts checked for tightness. The crankshaft alignment shall be checked when the engine is cold.

The exhaust temperature at normal full load shall be taken. These temperatures shall be within plus or minus $15^0$C of the manufacturer‘s standard exhaust temperature for full load when the correction of compression and firing temperatures has been made.

H. Such further tests as are reasonable to determine the compliance with specified requirements of controls, warning signals and other equipment not otherwise tested.

I. After completion of above test, perform sudden 60% applied load tests and check the response time and voltage dip.

J. Temperature measurements for the alternator during the above test shall be carried out in accordance with requirements of Clauses 76 of BS 2613.

K. A record shall be kept of the readings of all fixed and temporary instruments and gauges immediately before and after each ―running‖ test at reasonable intervals (in proportion to its duration) during each test. The record of readings taken at intervals for a period after certain test. The ambient temperature and other relevant data shall also be recorded in each case. On top of all the data taken on the above interval record, all the data including Voltage, Frequency, Current, Vibration and any data as required by the Engineer shall be continuously electronically recorded.

L. Should one or more of any series of tests resulted in the failure of the installation or any part of it to perform in accordance with the requirements of the Specification or Guarantee, the installation shall be deemed to have failed on initial test in that respect. The Contractor may then request the Engineer to amend the testing programme to allow time then to alter for modifications or adjustments to the installation to overcome the defect.

M. The Engineer will make such alternations to the testing programmes as is reasonable for this purpose and the unsuccessful test series shall be re-performed after the modifications and adjustments have been made. The Engineer at his discretion, require the re-performance of all or any of the other tests that were carried out prior to the making of modifications and adjustments.

N. Should the installation again fail to perform in accordance with the requirements of the Specification and Guarantee during the first or any further re-performance of any series of tests, the granting of permission to make further modifications and adjustments and to make further re-tests shall be entirely at the discretion of the Engineer.

O. The Contractor shall bear the full cost of conducting all such further re-tests including the reimbursement to the Engineer and other essential participants of their incurred in being present at, and/or providing for, such re-tests.

P. Should only any of series of three or more tests result in the failure of the installation or part of it to perform in accordance with the requirements of the Specification or guarantees and should this failure be of a minor nature only and no other faults be made evident the Engineer may, at his discretion and taking into consideration the results of the other tests of the series and of other series, accepted the overall result of the series of test as being successful.

Q. Should the installation fail to perform in accordance with the requirements of the Specification and Guarantee during the first or any further re-performance of any series of tests the Engineer may at any stage deem the installation to have failed on test and be may reject the whole or any part of it.

R. If during the course of testing any evidence of structural or mechanical failure of any parts of the installation should become apparent the Engineer, may at his discretion permit the Contractor to carry out rectification or modification and re-testing but with the full cost of all re-test, including the first, being borne by the Contractor.

S. Should the Engineer consider any structural or mechanical fault or failure to be such that on site rectification nor modification would not be desirable or that such fault or failure reveals and undesirable inherent defect of manufacturer detail, or should a fault or failure occur after rectification or modification, he may reject the whole or any part of the installation.

T. No extension of the Contract Period shall be granted by reason of any extension of testing period to permit rectification, modification, adjustment or retesting of the installation.

## 3.04 SITE TEST

A. Upon the delivery to the site and if the generator set is required to re-assemble on site, similar tests shall be carried out by the Contractor to ensure that the performance is not degraded. The tests, but not limited to are:

1. Diesel engine-Generator coupling and shafts alignment.
2. On load ‗mains failure' simulation test
3. Safety devices test
4. Remote monitoring
5. Auxiliary contacts etc.
6. Load tests.
7. BMS interface test

B. Load tests may be carried out through building load and/or Contractor load bank. Cost to arrange for the load for purpose of testing shall be included in the Contract.

## 3.05 PAINTING OF PIPE WORK

A. All pipe work, other than buried pipes, shall be painted immediately after installation with at least one coat of red primer and two (2) finishing coats of best quality aluminum paint approved by the Contractor. The color will be determined by the Engineer on site.

## 3.06 VIBRATION CONTROL

A. The complete generator assembly shall be isolated on static deflection unhorsed spring-neoprene in series isolator with non-skid neoprene pads. Start-up and shut down rocking restraint snuffers shall be provided at four corners of base frame.

B. All fuel line pipes shall be cushioned with a layer of harness and neoprene pad at attached points.

C. All pipe work and engine silencers shall be suspended on static deflection spring-neoprene in-series hangers.

D. Detail calculation and proposal for justifying the size and provision shall be provided for Engineer's review prior to the installation.

# HVAC WORKS

# ELECTRICAL OPERATED SCREW CHILLER

## 1. SCOPE

Supply, Installation, Rigging, Lifting, Placement, testing & commissioning of Electrical operated Screw chiller complete in all respect ready to operate as per schedule and specification herein and as per instruction of Consultant.

## 2. GENERAL

Supply, Installation, Rigging, Lifting, Placement, testing and commissioning of VFD/VSD driven electrical operated, water cooled, screw type chillers based on HFC-134a, confirming to NPLV value calculated to ARI standard 550/590-98, 575 for sound rating, minimum efficiency as per ASHRAE 90.1 or equivalent Eurovent certified performance rated or other Japanese code or Din standard.

The chiller shall be an imported item and shall be from approved manufacturers complete in all respects and ready to operate as per schedule and specified herein. The unit shall be supplied with the manufacturer‘s performance guarantee and factory performance test report.

Evaporator side fouling factor shall be min 0.00010 (ft² ºF hr/Btu) and Condenser side fouling factor shall be min 0.00025 (ft² ºF hr/Btu).

Evaporator and Condenser side pressure drop shall not exceed 15 ft of water at the specified water flow rate.

The unit shall be capable of providing chilled water at the specified conditions, as indicated in the schedule.

The unit shall be shipped as a single piece assembled equipment with a factory balanced refrigerant charge inside of the unit.

The intent of specification given here under and, schedule of equipment is to ensure the delivery of chillers machines at the site in complete operational conditions satisfactory to owner & consultant.

## 3. DESCRIPTION

### 3.1. CHILLER

The chiller shall include single or multiple screw type compressor, Positive pressure design to operate the entire system above atmospheric pressure at all the time. In the event of small leak, refrigerant escapes from the chiller to the atmosphere, which allows easy detection and repair. low noise level,

A low vibration level, chlorine-free R134a refrigerant, Shell and tube type water cooled condenser with integral sub -cooling, Shell and tube type insulated evaporator with dual independent refrigerant circuits.

Chiller shall be suitable for direct expansion of refrigerant.

Chiller and Condenser shell confirm to ASME Code viii, Division 1 code for Unfired pressure vessel. The ASME symbol ¯U‖ must be stamped at every appropriate part of chiller. Chiller shall be provided with 2 inches of Urethane foam insulation and covered with 22 gauge G.I jacket. Chiller shall be designed for 150 psig working pressure on refrigerant side and 200psig on waterside.

A vapor activated alarm system consisting of all alarm, sensors, safeties as required by ANSI/ASHRAE 15 safety code for mechanical refrigeration system (Latest edition) shall cover.

External refrigerant storage tank and pump out unit.

High efficiency purge unit.

Back up relief Valve.

Chiller assembly shall be proof tested at a minimum 232 Psig (1600Kpa) and leak tested at 185 Psig (1276Kpa) with a tracer gas mixture on the refrigerant side. The leak test shall not allow any leak greater than 0.5 oz/year of refrigerant. The water side of each heat exchanger shall be hydrostatically tested qt 1.3 times rated working pressure.

## 3.2 COMPRESSOR AND MOTOR

Accessible Semi-Hermetic, screw type compressor with 1450 rpm, 380-440 volts A/C, 50 cycle,3 phase motor. The compressor shall soft start unloaded, and through infinitely variable capacity control achieve the demand load to ensure a constant evaporator leaving water temperature without any fluctuations from the required set point.

Compressor Motor shall be of hermetic, Liquid refrigerant cooled, squirrel cage, induction type suitable for specified voltage and cycle on the equipment. Motor shall be able to operate at 122 deg F without overloaded.

Compressor impeller shall be dynamically balanced and over speed tested by the manufacturer at the minimum of 120% of design operating speed. Each compressor assembly shall undergo a mechanical run-in test to verify vibration levels, Lubrication pressure and temperature are within acceptable limits.

Each compressor assembly shall be proof tested at a minimum 232 Psig (1600Kpa) and leak tested at 185 Psig (1276Kpa) with a tracer gas mixture on the refrigerant side. The leak test shall not allow any leak greater than 0.5 oz/year of refrigerant.

Lubrication system shall be forced feed type utilizing a positive displacement pump with filters.

Motor shall be suitable for voltage fluctuation plus or minus 5percent of name plate voltage.

Compressor, Motor and transmission shall be hermetically sealed in to a common assembly andarranged for easy field servicing.

Internal compressor parts must be accessible for servicing without removing the compressor base from the chiller. Connections to the compressor casing shall use O-rings instead of gaskets to reduce the occurrence of refrigerant leakage.

Connections to the compressor shall be flanged or bolted for easy disassembly.

The high speed thrust bearing shall be of tilting pad, multi shoe, kingsbury type with individuallyreplaceable shoe.

The low speed shaft thrust bearing shall be of tapered land type.

The compressor design shall include a balancing piston to offset impeller thrust forces.

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The gear thrust load shall act opposite to impeller thrust load. Gear shall confirming to AGMAstandard, quality II.

The variable inlet guide vanes at the inlet of impeller shall capacity modulation from 100% to 15% of capacity, with 2.5 deg F drop in entering condenser water temperature per 10% capacity reduction, while also providing pre-whirl of the refrigerant vapor entering the impeller for more efficient compression at all loads.

Compressor shall be provided with a factory installed lubrication system to deliver oil under pressure to bearings and transmission. Include in the system shall be:

## 3.3 CONDENSER & COOLER

Water cooled shell and tube type suitable to withstand pressure drop as per design. Each in separate shells. Units shall be fabricated with high-performance tubing, steel shell and tube sheets with fabricated steel water box with ANSI raised face flanges.

Marine water box have standard Victaulic grooves with tube access for inspection, cleaning, and removal dismantling of water piping.

Tubing shall be copper, high-efficiency type, with integral internal and external enhancement.

Tube shall be rolled into tube sheets and shall be individually replaceable. The tube sheet holes shall be double grooved for joint structural integrity. Intermediate support sheet spacing shall not exceed 36 inches.

Water boxes and nozzle connections shall be designed for 150 Psig. Nozzles should have grooves to allow use of ANSI raised face flange connection.

The tube sheet of the cooler and condenser shall be bolted together to allow for field disassembly and reassembly.

Factory fitted water differential pressure switches to be provided, with water thermal dispersion flow sensors.

Adjustable type pressure relief valve shall be installed at each heat exchanger.

Water box shall have vents, drain, and covers to permit tube cleaning.

Cooler shall be designed to prevent liquid refrigerant from entering the compressor.

Tubes shall be individually replaceable from either end of the heat exchanger without effecting the strength and durability of the tube sheet and without causing leakage in adjacent tubes. Manufacturer to incorporate the pressure drop in the condenser.

## 3.4 CAPACITY CONTROL

The unit shall operate fully automatic the compressor shall start unloaded, and through infinitely variable capacity control achieve the demand load to ensure a constant evaporator leaving water temperature without any fluctuations from the required set point.

The system will automatically adjust the output to the cooling requirements without requiring any manipulation by the operator. The unit capacity should be automatically adjustable between 15% to 100% of the full load capacity and during partial load operation.

The capacity control system shall be electric or electronic as recommended & supplied by the chiller manufacturer, completely factory-assembled on the chiller and tested. An automatic start/stop thermostat shall stop the chiller when chilled water outlet temperature falls 1.1C° below and starts when rises 3.5°C above the specified temperature.

## 3.5 ELECTRIC / ELECTRONIC CONTROL PANELS

The unit shall be suitable for operation on 380 Volts, 50Hz, 3-Phase electric power and the control circuits will be suitable for 220 Volts, 50Hz, 1-Phase electric to minimize external wiring required at site. Each machine shall have a separate power and control sections, completely factory-wired. and mounting in/on NEMA 4 /IP55 encloser.

The unit shall include control fuses, breakers, Solid stat over load relay, solid stat instantaneous under / over voltage drop out relay, on/off switch, time delay combination to prevent simultaneous starting of two compressors or multiple chillers, a lead lag and sequence kit for parallel sequencing of chillers (in case of 2 or more chillers),a three position individual refrigerant circuit( ON-OFF-PUMPDOWN) selector switch, freezing protection controls, low oil pressure cut off, indication and alarm,

Recycling pump down circuit, provision for remote wiring in a remote alarm device, an emergency stop switch.

Microprocessor based safety and automatic control panel capable to interface Automatic building management control system. Display of all information shall be shown in the English language on a 40-character alphanumeric display.

**Warning conditions:** The Control Center shall provide a warning annunciation when appropriate, under the following conditions: low refrigerant pressure, high refrigerant pressure, high or low entering condenser water temperature, low oil pressure, over current tripping etc.

Security access code shall be provided for operator to program set points or to choose local, remote, or service modes of operation.

**Building Management System (BMS) Interface:**

The chiller controls shall be electronic based and shall be capable of being interfaced with the BMS through RS 232, and shall be able to communicate all data accessible from the keypad to a remote integrated ODC processor through a single shielded cable, this information will include all unit temperatures, pressures, safety alarms, and status readouts for complete integrated plant control, data logging, and local/remote display of operator information, start/stop the unit, etc., further the chillers should accept the following industry standard remote capacity & set point control signals. Operating software shall be window based, and operating language must be English.

## 4. FACTORY PERFORMANCE TEST

Chiller shall be factory performance tested by the manufacturer in the cooling mode as per procedure given in ARI standard 550/590 at specified full load and part loads conditions. and provide test report through mail and along shipping documents.

## 5. COMMISSIONING AND TESTING:

A Factory trained engineer provided by the supplier, duly authorized by the chiller manufacturer, shall commission the units and give instructions at the site to the Owner operating personnel for a period of at least two weeks. The machine shall be commissioned as per manufacturer's procedures and the supplier shall furnish a startup log indicating operating and safety control functions are mentioned. The machine shall be subjected to appropriate tests to determine their capacity & performance. The chiller shall be subjected to recommend specified tests and these test reports shall be submitted to the Consultant by the supplier in suitable test forms.

## 6. SPARES FOR WATER CHILLER

The Manufacturer will provide necessary spares parts which required for at least two years smooth operation.

The following spares shall be supplied a s recommended by the manufacturer.

| | |
|---|---|
| Oil Filter and replacement gasket and O ring Set | 1 Set |
| Liquid Line Filter Dryer Core | 1 Set |
| Evaporator inlet and outlet Temperature Sensor | 1 Set Each |
| High/Low Pressure Transducers | 1 Set Each |
| Compressor Line Fuse | 1 Set |
| Controls Primary Transformer protection Fuse | 1 Set |
| Auxiliary Circuit Protection Fuse | 1 Set |
| Phase Monitor Protection Fuse | 1 Set |
| Evaporator Heater Fuse | 1 Set |
| Electronic Expansion Valve with Sensor | 1 Set |

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| | |
|---|---|
| Oil Pressure Transducers | 1 Set |
| Main Card of Microprocessor | 1 Set |
| One Complete Charge of Refrigerant Oil | 1 Charge |
| One Complete Charge of Refrigerant R134a | 1 Charge |
| Packing Kit | 1 Set |

## 7. PRICED SPARES PARTS LIST

The tenderer shall also supply along with tender the priced spare parts list for the chiller, with the priced valid for a period of one year. The complete spare parts manual shall be submitted which shall indicate the parts numbers and show exploded view.

## 8. SHIPPING

All material/components are prefabricated piece marked and boxed in rugged export crating. Maintenance and assembly instructions in English shall be provided.

## 9. EXECUTION

### General

The equipment has to be installed in compliance with the following requirements.

Prior to work, check the specifications, models, quantity, ex works test reports and conform its description of the equipment and fittings piece by piece and keep detailed record.

Organize installation to the installation specification from the manufacturer.

### Installation

Provide proper protection at all rotating parts like coupler or protruding screws to ensure thesafety of the maintenance people at work.

For electrical connection, refer to related working drawings and specification from themanufacturer.

When the adjusted units are shipped and delivered to the site, and unpacked for acceptance, inspect the appearance of the equipment, count the parts and check the accompanying documents and conformity certificate. The contractor shall work immediately with people from related parties to examine the air-tightness of the units. Prior to installation, the contractor shall familiarize himself with the working drawings, codes and related technical documents, and work out the construction scheme.

The foundation and shock-damping measures for the Chiller unit shall be provided as per the data from the manufacturer when the equipment is ordered. Before the installation of the unit, the contractor shall check if the equipment foundation and shock-damping measures meet related requirements, and properly keep the record. Install the Chiller at the pre-determined location, and make sure to provide sufficient space for the operation and maintenance.

Provide sufficient permanent lifting eyes for installation and maintenance. The bearing capacity of the lifting tools and steel wire ropes shall be higher than the weight of the unit.

People shall stand away from under the boom hoist and the weight to avoid injury and death.

Avoid abrupt movement or stop during the installation. The horizontal deviation in installing the unit shall be less than 1/1000.

All fittings liable to corrosion shall be subject to anti-corrosion treatment and coated with appropriate anti-rust paint. Moreover, during the installation, avoid electrolytic effect resulting from the direct contact between different metals.

Clean the complete system before the operation of the equipment.

# HOT WATER HEATER AND ACCESSORIES

## 1. SCOPE

Supply, Installation, Rigging, Lifting, Placement, testing and commissioning of dual Fuel (Natural Gas & High speed Diesel Oil) operated Flexible tube Hot water heater for space heating complete with automatic controlled with all safety controls and accessories, suitable for continues operation and of minimum capacity as specified in schedule of equipment.

As specified capacity of heating pressurized hot water, temperature range from 58ºC to 70ºC +/- 5ºC.

The hot water heater shall able to meet the capacity from 10% to 100% of Hot water.

The Boiler shall be of flexible water/smoke tube multi-pass design of high efficiency (minimum 80%) including complete sufficiently insulated with adequate refractory and insulation to avoid adversely raising the adjacent plant room temperature maximum 5ºC above ambient condition.

The plant room environmental condition consider 122ºF in peak summer and dust-laden, so all the instrumentation and accessories shall be selected accordingly.

The hot water heater shall be completed in all respects and ready to operate as per schedule and specified. The unit shall be supplied with the cover of all manufacturer's performance guarantee and factory performance test report.

The main fuel for the heater shall be natural gas supplied by Sui Southern Gas Co. Standby shall be high speed diesel oil and burner shall be suitably designed for dual – fuel operation,with automatic control of leaving hot water temperature, to meet 10% to 100 % heating capacity of full load rating.

It is specifically informed that the supplier shall be responsible to ascertain the properties of the Natural Gas & Diesel oil available at the location of the project and ensure that the equipment supplier meets the specified performance with these fuels.

The unit shall be capable of providing hot water as needed, at the specified conditions, as indicated in the schedule.

The unit shall be shipped as a single piece assembled equipment to eliminate any damages during shipment.

The intent of specification given here under and, schedule of equipment is to ensure the delivery of equipment at the site in complete operational conditions satisfactory to owner & consultant.

## 2. Controls

- Low water cut-off with manual reset.
- Safety pressure relief valve.
- 100mm dial 10-100 Deg C range temperature gauge.
- 100mm dial pressure gauge.
- Combination Temperature & Pressure indicator gauge.
- Water inlet &outlet digital temperature indicator.
- Operating Temperature controller.
- Hi-Temperature cut-off with manual reset.
- Fuel Train.
- Low water cut-off with manual reset.
- ASME rated hot water relief valve.
- Hi-Water Temperature Alarm Bell, with mute switch.
- Flame Failure Alarm Bell.
- Ignition transformer.

## 3. HEATER SECTION

Leak Guard type double wall steam to water tank heat exchanger.
Construction in accordance ASME Section VIII.
Bundle of U tube, ¾ x 20BWG Copper construction.
High degree of flexibility in material to meet varying conditions.Multi pass construction.
Suitable for specified pressure ratings.

### CONTROLS

- Control valves for Natural Gas/High Speed Diesel Oil.
- Pressure reducing valve.
- Fine line strainer.
- Automatic temperature control system. A hot water supply temperature controller in thestorage tank shall control the operation of heater section.

## 4. QUALITY ASSURANCE REQUIRMENT

- Furnace Volume and construction shall be of insulated Gas-tight casing with suitable designmatching the requirement of the selected burner.
- All heater refractories (If Required) shall have minimum 70% alumina content.
- The construction of heater shall be of ASME Standard Section-VIII.
- Pressure Vessel testing shall be recommendation of international standard.
- Welded (RFWN) Connections shall be provided.
- Lifting Lugs shall be provided as per Code.
- The heater shall be brand new product complete with name plate from the original manufacturer indicating the name of the manufacturer, type of the equipment, unit No. and related technical data. The ex-works test shall be performed to the latest testing standard.

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- The equipment supplied shall be product from a manufacturer with min. 10 years of experience in manufacturing this type of equipment, and related heater shall comply with related technical requirements and all the relevant certification agencies.

- The warranty period of the product will be min 18 month starting from the completion date.

- The heater shall have a service life of min. 20 years in normal service.

- The manufacturer shall repair faults arising during the installation and trial run of the heater as soon as possible followed by retest.

- The Employer/Consultant may visit the manufacturing facility any day in working hours and inspect the manufacturing procedure, assembly, cleaning, packaging and other processes of the equipment at any time after signing the contract without prior notice.

- All equipment and its pipes shall be assembled by personnel with 5 and more years of experience in similar works or appropriate qualification certificates.

- Electric welders should be subject to test or examination of welded products on site and appropriate qualification certificates.

- The contractor shall inspect all welding processes and provide quality evidences.

## 4. LICENCE & CERTIFICATION

- The Manufacturer is fully responsible for manufacturing, ,testing, commissioning, operation and accessories shall be as per standard, codes and as per Pakistan Boiler Laws and to the complete approval of Chief Inspector of Boiler, Govt. of Sindh as required for 60 psigoperating pressure of hot water.

- In case of the Inspection Authorities do not cover this type of heater for approval requirement, the Manufacturer and the Contractor shall be fully responsible for arranging suitable certificate to the effect issued by the boiler inspector. .

## 5. DESCRIPTION

### 5.1 Arrangement.

- The furnace dimension and design shall ensure that complete combustion of the fuel takes place within the furnace limits with no flame impingement on side wall, roof or target wall.

- For Oil Firing (Stand by Fuel) minimum distance between burner gun tip and nearestfurnace surface along the burner throw shall be 0.35 ft/MMBTU/HR/burner gun based on the design fuel higher calorific value.

- The hot water heater and auxiliary equipment, with the exception of the forced draft fansand drivers shall be designed for a minimum of 15% excess air.

## 5.2 Headers

- Both headers and connecting water tubes of flexible design shall be laid out to ensure safe and adequate circulation under all load fluctuation.

## 5.3 Structure & Casing

- Insulated Casing shall from a pressure tight furnace with approved refractory inside to protect insulation and outer casing from flue gas contact. The casing tightness to be confirmed by 10 inch water column air tight pressure in factory.

- One access door, minimum size 12 1/2 inches x 23 inches shall be provided for the furnace.

- Drain shall be provided at the low point of the heater furnace and back side of permit removal of flue gas deposit during water washing. Drain shall be totally sealed to avoid casing overheating and flue gas by-passing.

- Observation hole, minimum size of 2 inches x 4 inches, shall be provided as to permit visibility of all burners and furnace surface.

## 5.4 Plate forms and Stairs

- Hot water heater casing structure shall be braced to provide access to heater roof throughcat ladder (If required) for access to all equipment and openings requiring servicing or operator attention.

- Guard railing, safety cages, etc shall be constructed of steel and shall meet all safety requirement.

- All the above components will be assembled on a MS channel skid pre piped with necessary valves, Controls and pre wired for installation at the site and ready to operate.

## 5.5 Burners

The heater shall be provided with suitable duel fuel burner to operate on the gas (HCV/LCVof the local gas) and high speed diesel oil as indicated in schedule and shall be complete with automatic controls to operate chiller with in specified limits and to provide alarm for minor deviations within the operating limits or automatic shut off when deviation from specified operating limits. The major burner system functions shall be including, but not confined to the following.

a) Pilot and Main Burner with fuel interlock switch and automatic safety and mechanicalremote shut-off valve.

b) Flame Scanners with photoelectric supervision sensors

c) Ignition Transformers, with spark ignition indicators

d) Burner control panel for pilot and main ignition duties, deviation cycle control, master control switch, relays, gauges, electronic/electrical interlocks, indicators and automatic shutdown for following:

   i. Ignition failure

   ii. Forced draft failure

   iii. Main Flame failure

   iv. Low / high, gas pressure

e) Gas train shall be suitable for the gas pressure on site (supplier to verify). The gas train shall contain the following component: manual shut off locks, main gas pressure regulator, low & high gas pressure switches, two leak test corks, burner manifold gas pressure gauge, two main motorized gas valves one with proof of closure interlock switch for gas inputs above as mentioned and one normally open vent valve sized to requirements.

f) Fuel flow meter

g) Pressure regulating valve assembly

## 5.6 Capacity Control

The hot water heater shall operate fully automatic after it has been started and will automatically adjust the output to the heating requirements without requiring any manipulation by the operator. The unit capacity should be automatically adjustable between 10% to 100% of the full load capacity and during partial load operation; heater shall allow reduction of fuel consumption with maximum efficiency.

The capacity control system shall be electric or electronic as recommended & supplied by the boiler manufacturer, completely factory-assembled on the boiler and tested. An automatic operation shall be based on leaving hot water temperature as specified.

## 5.7 Electrical Control Panel

The unit shall be suitable for operation on 400-380 Volts, 50Hz, 3-Phase electric power and the control circuits will be suitable for 220 Volts, 50Hz, 1-Phase electric to minimize external wiring required at site. Each equipment shall have a completely factory-wired and mounted control panel that shall include a total of three (3) enclosures; a Power Panel, a Burner Control panel and Electronic Control Panel:

The heater shall have totally enclosed control panel and all component shall be selected to operate satisfactory in ambient up to 55 Deg C.

### i. Power Panel

The Power Panel enclosure shall be NEMA 1 and shall house the following components: single point wiring connection for incoming power supply non fused disconnect switch motor starters, complete with current and thermal overload protection for fan etc (current overloads only); a Control Transformer.

ii. **Burner Control Panel**

The Burner Control Panel enclosure shall be constructed of 16 gauge steel and shall be equipped with a hinged and removable front access door and shall house all combustion related safeties and control logic. The Burner Panel shall be designed to interface directly with the ISN Para Flow Control Center Panel to provide integrated burner control for the chiller heater. The Burner Control Panel shall be mounted and prewired to the chiller-heater and shall include the following components:

- Flame Safeguard
- Burner On/Off switch
- Control power transformer
- Motor starters, complete with current overload
- Protection for blower motor.
- Electrical transient suppressors
- Alarm bell
- Flame failure indications contacts
- Exhaust gas temperature limit switch
- Indicating lamps, labeled as follows
- Call for operation
- Ignition on
- Main Fuel
- Flame failure

Warning conditions

- The Control Center shall provide a warning annunciation and, when appropriate, limit conditions.

Safety controls

- The Control Center shall include safety logic designed to protect the hot water heater from damaging malfunctions. Complete safety annunciation shall be displayed for each shut-down by pressing the status key. This information shall include day, time and reason for shutdown.

## 5.8 Burner Management System

- A burner management system designed on fail-safe concept, shall be provided consisting of integrated system of dual flame detectors, interrupted spark-ignited pilots, shutdown devices, interlocks, combustion control limits including environmental controls, alarm and shutdown valves to assure safe condition of light-off and to prevent unsafe condition from developing during operation.

- Inspection and check out of the assembled system with necessary simulated operation prior to commissioning shall be witnessed by owner engineer/consultants at site, prior to full inspection and check-out of the complete system on start-up, to check all logic functions, logic input and outputs alarm etc.

- Digital programming of operating set points from the keypad shall include leaving hot water temperature, pull down demand limiting, remote reset temperature range daily start/stop scheduling of chiller and water pumps with separate holidayschedule.

- Security access code shall be provided for operator to program set points or to choose local, remote, or service modes of operation. Manual control of the burner firing rate and all pumps shall be provided through separate buttons in theservice mode of operation.

### 5.9 Building Management System (BMS) Interface:

The hot water heater controls shall be electronic based and shall be capable of being interfaced with the BMS, and shall be able to communicate all data accessible from thekeypad to a remote integrated ODC processor through a single shielded cable, this information will include all unit temperatures, pressures, safety alarms, and status readouts for complete integrated plant control, data logging, and local/remote display of operator information, start/stop the unit, etc., further the chillers should accept the following industry standard remote capacity & set point control signals. Operating software shall be window based, and operating language must be English.

### 5.10 Insulation

- Mineral wool high temperature insulation of minimum 4 inches thick and specified density shall be applied to external hot water heater surfaces and flue gas duct connections, to ensure maximum allowable outer surface temperature to be 30ºC above ambient.

## 6. FACTORY PERFORMANCE TEST

Hot water storage heater shall be factory performance tested by the manufacturer in the heating mode as per procedure given in ASME code on full load/partial load, 10-100% operating parameters & submit report through mail and shipping document

Factory Test Report, which will include the following:

- Flow rate of hot water
- Entering and Leaving water temperature
- Gas consumption rate at part load & full load
- COP confirmation

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## 7. COMMISSIONING AND TESTING:

A Factory trained engineer provided by the supplier, duly authorized by the heater manufacturer, shall commission the heater and give instructions at the site to the Owner operating personnel for a period of at least two weeks.

The hot water storage heater shall be commissioned as per manufacturer's procedures and the supplier shall furnish a startup log. indicating, operating and safety control functions are mentioned. The boiler shall be subjected to appropriate tests to determine their capacity & performance.

The heater shall be subjected to recommend specified tests and these test reports shall be submitted to the Consultant by the supplier in suitable test forms.

## 8. SPARES FOR HOT WATER BOILER

The following spares shall be supplied as recommended by the manufacturer.

| | |
|---|---|
| Electronic probe type low water cutoff | 1 Set. |
| Modulating Temperature Controller | 1 Set. |
| Flow Switch | 1 No. |
| Temp Sensor | 1 No. |
| Temp Sensor (Ext/Gas) | 1 No. |
| Press Switch | 1 No. |
| Fuse | 1 No. |
| Flame Detector | 1 No. |
| Control Transformer | 1 No. |
| Pilot Solenoid valve | 1 No. |
| Control Motor | 1 No. |
| Shut-off Gas Valve | 1 No. |
| Shut-off Diesel Oil Valve | 1 No. |
| Pilot Regulator | 1 No. |

Other spares as recommended by the Manufactures for two years normal operation (Tenderer to specify)

## 9. PRICED SPARES PARTS LIST

The tenderer shall also supply along with tender the priced spare parts list for the chiller, withthe priced valid for a period of one year. The complete spare parts manual shall be submitted which shall indicate the parts numbers and show exploded view.

## 10. EXECUTION

### General

The equipment has to be installed in compliance with the following requirements.

Prior to work, check the specifications, models, quantity, ex works test reports and conformitydescription of the equipment and fittings piece by piece and keep detailed record.

Organize installation to the installation specification from the manufacturer.

Installation

Provide proper protection at all rotating parts like coupler or protruding screws to ensure thesafety of the maintenance people at work.

For electrical connection, refer to related working drawings and specification from themanufacturer.

When the adjusted units are shipped and delivered to the site, and unpacked for acceptance, inspect the appearance of the equipment, count the parts and check the accompanying documents and conformity certificate. The contractor shall work immediately with people from related parties to examine the air-tightness of the units. Prior to installation, the contractor shall familiarize himself with the working drawings, codes and related technical documents, and work out the construction scheme.

The foundation and shock-damping measures for the Boiler unit shall be provided as per the data from the manufacturer when the equipment is ordered. Before the installation of the unit, the contractor shall check if the equipment foundation and shock-damping measures meet related requirements, and properly keep the record. Install the boiler at the pre-determined location, and make sure to provide sufficient space for the operation and maintenance.

Provide sufficient permanent lifting eyes for installation and maintenance. The bearing capacity of the lifting tools and steel wire ropes shall be higher than the weight of the unit.

People shall stand away from under the boom hoist and the weight to avoid injury and death.

Avoid abrupt movement or stop during the installation. The horizontal deviation in installing theunit shall be less than 1/1000.

All fittings liable to corrosion shall be subject to anti-corrosion treatment and coated withappropriate anti-rust paint. Moreover, during the installation, avoid electrolytic effect resulting from the direct contact between different metals.

Clean the complete system before the operation of the equipment.

## 11. Relevant Code & Standard

Following are relevant standards and codes are applicable to this sections:ASTM American Society of Testing & Materials Section VIII.

Equivalent to mentioned codes and standards may be approved by the Consultant on the provision of evidence of equivalent by the contractor.

# COOLING TOWER

## 1. SCOPE

Supply, Installation testing & commissioning of CTI certified and approved, FRP construction with internal piping Cross-Flow type Cooling Tower complete in all respect ready to operate as per schedule and specification laid herein and as per instruction of Consultant.

## 2. TYPE

The cooling towers shall be fully tropicalized, of the, FRP construction, Induced draft, Cross- Flow square, Side intake Vertical discharge type. They shall be fabricated completely from corrosion-resistant materials and shall be designed for ease for maintenance particularly for cleaning of the in-fill, drift eliminators and basin.

Each cooling lower shall be guaranteed to cool the minimum quantity of water at the conditions a s specified in the Equipment Schedule for the effective operation of the chiller equipment. Manufacturer selection sheet shall be submitted.

Cooling Towers rated by the recognized institutes such as Japan Cooling Towers Institute (JCI) or Japan Industrial standard (JIS) or Cooling Tower Institute (CTI)

## 3. DESCRIPTION

The cooling Towers can be of single or more cell having common basin with one or more fans for optimum energy usage at partial load conditions and shall be suitable for the space provided for in the drawings.

Each cell of the cooling tower shall be essentially consisted of an axial fan driven by a TEFC, IP-55 protection grade, F insulation grade motor through a set of V- belts, the upper water basins with spray boxes, the body cased and louvered such to allow uniform air flow and prevent outward water splashing. The lower water basin shall be fitted with standard common connection for make-up. Quick fills, bleeds drain and overflow.

All multi-cell towers offered must be fully independent and compartmentalized to allow shutdown of individual cell for repair without affecting the other cells in operation.

The tower shall be designed to with stand at least for a wind pressure of 1.5 kPa of projected area. The normal wind velocities at the site vary between 15 to 50 km/Hr but winds up-to 170 Km/Hr may occur. Columns, bracing and structural connections shall be of such design and construction as to with stand maximum stresses imposed on the frame work by the maximum wind pressure and earth quake of 8.5 at Rectal Scale.

## 4. CASING

The cooling tower casing shall be constructed of fiberglass polyester (FRP), which shall be made with UV-resistant polyester resins. All internal FRP surfaces shall have a smooth finish ensuring ease of Cleaning. Hot dip galvanized metal members shall be used for casing supports and structure.

## 5. BASIN

The basin shall be moulded of FRP with all edges rounded and sloping to the drain outlet. The basin shall be equipped with provision for connection to the suction; drain, overflow, equalizing and quick fill pipes. Easy and quick access to clean the basin shall be possible from outside and as well from inside of the cooling tower. Strainer, make-up water valves and adjustable water level control devices shall be provided.

## 6. AIR INLET LOUVER'S

Air inlet Louvers shall be fabricated with PVC or Aluminum and designed to prevent water splashing out and objects from entering the water basin. The louvers shall be easily removable to provide access for cleaning.

## 7. ACCESS

Easily removable access door(s) shall be provided to allow for inspection, maintenance and cleaning of the wet deck surfaces, eliminators, nozzles and mechanical parts. Ladder, removable fan guards, removable guards for all exposed moving parts and all other accessories for the safety of operation shall be provided.

## 8. WET DECK SURFACES

The infills, which shall be made of PVC films, shall be impervious to rot. Decay or biological attacks. It shall be supported such that the bottom of the fill is above the water level of the tower. Fills can with stand at a maximum water temperature of 122°F.

The infills shall be arranged into standard modules/blocks. These standard module/blocks shall have adequate rigidity and strength to stand independently or self-supporting when arranged in rows. They shall be raised at minimum of 50mm above the cold water basin to facilitate the servicing and cleaning of the tower basin and in-fill.

No other additional forms of supports shall be allowed to hold the infills in a manner that may be detrimental and affects the flexibility of the tower for emergency repair or replacement of the module/block of infills whilst the tower is still in operation mode.

The installation and holding method to the infills panel assembly shall be such that it does not collapse or disengage from the panel assembly for a period of not less than 5 years. The contractor shall obtain a written guarantee from the manufacturer for the above requirement.

## 9. WATER DISTRIBUTION SYSTEM

Factory designed internal piping system for the distribution of hot water shall be provided such that there will be no other forms of distribution piping necessary at the top of the cooling towers not water basin.

Water shall be distributed evenly over the wet deck surfaces by a low pressure, stationary non-rotating type water distribution system. The header and branches shall be made of heavy duty UV-resistant PVC and they shall be equipped with ABS plastic nozzles with large openings to prevent clogging. Water distribution system using rotating sprinkler heads shall not be acceptable.

## 10. DRIFT ELIMINATORS

Drift eliminators shall be provided to control the drift loss to not more than 0.01% of the water circulation rate. The drift eliminators shall be made from UV-resistant PVC and furnished in light weight removable sections.

## 11. HOT WATER BASIN

The hot water basin at the top of the cooling towers shall be provided with cover to prevent alga growth and ingress of foreign materials such as falling leaves into the system.

## 12. FANS

The fans shall be of the propeller type. Dynamically balanced and aerodynamically designed to provide efficient use of power and quiet operation. The fan blades and hub shall be fabricated with corrosion resistant heavy-duty cast aluminum alloy material of FRP. Fanguards shall be provided made of SUS-304.

## 13. FAN MOTORS

The fan motors shall be of drip-proof design with a 1.15 service factor. The fan motor shall be provided with a protective enclosure, which shall allow for convenient and easy access for adjustment of belt tension, lubrication and changing of motors. The motor shall be suitable for outdoor services on 400-420 volt 3 phase 50,60Hz-power supply. The motor shall haveminimum class ¯F‖ installation and TEFC, IP55 protection grade.

## 14. METAL PARTS

All internal metal parts of the cooling towers including fan netting, supports, bolts, nuts, washers, which are in contact with the condenser water, shall be constructed of stainless steel316 material.

Metal parts of tower structure shall be of hot dip galvanized.

## 15. VIBRATION ISOLATORS

The cooling towers shall be isolated from the building structure by vibration isolators as per the manufacturer‘s recommendations.

## 16. NOISE LEVELS

The noise level from the combined operation of the two cooling towers shall not exceed the noise levels permitted by the local Authorities. Notwithstanding this, the maximum levels shall not exceed the following at the boundary of the premises, with both units in operations:

| Time | Noise | Level |
|---|---|---|
| 6AM - I0PM | 65 | dbA |
| 10PM - 6AM | 60 | dbA |

## 17. BLEEDING – OFF ARRANGEMENTS

The cooling towers shall be fitted with arrangement for bleeding-off water to prevent excessive concentration of dissolved solids and to minimize scale formation.

## 18. MAKE – UP WATER FLOAT VALVES

The make-up water float valves shall be of the type approved by the water pert.

## 19. EQUALIZING PIPES

Equalizing pipe, constructed with UV-resistant PVC pipes, shall be installed between the cooling towers and they shall be adequately sized to prevent the problem of water depletion or overflow of the cooling tower basins during parallel operation of the cooling towers. A drain cock shall be provided at the bottom of the equalizing pipe shall be for drainage from the pipe.

## 20. SHIPPING

All material/components are prefabricated piece marked and boxed in rugged export crating. Maintenance and assembly instructions in English shall be provided.

## 21. SPARE PARTS

Furnish the following spares as recommended by the manufacturer.

| | | |
|---|---|---|
| 1 | Bearing | 1 Set with each Cooling Tower. |
| 2 | Fan-Assembly | 1 No with each cooling Tower. |
| 3 | Fan Motor | 1 No. for each type of rating. |
| 4 | Fill | 10 % of total cooling tower cap. |
| 5 | Eliminator | 10 % of total cooling tower cap. |

# AIR HANDLING UNITS

## 1. SCOPE

Supply, Installation testing and commissioning of modular type Eurovent Certified/ AHRI certified Air Handling Units of various types and capacities as per schedules, drawings, specifications and instructions of the consultant.

## 2. DESCRIPTION

The Double Skin Modular, Extra Low Noise, Ducted, Horizontal/Vertical Floor Standing, VFD/Non VFD operated as specified Air Handling units shall be of draw through type with configuration as shown on the drawings. Each modular section will be factory built and assembled at site by the supplier to make a complete unit as per schedule and drawings.

Air Handling Unit shall be provided in various sections/modules as per schedule. Each section serving a specified purpose, such as fan section, coil section, humidification, mixing box section, filter section etc shall be modular type & capable of being attached to each other with the airtight joint. All sections shall be mounted on galvanized structural base extending to full length of air handling unit.

Capacities shall be not less than as shown on the equipment schedule and ratings shall be in accordance with AHRI Standard 430 for fans and 410 for cooling coils.
inclusive of the following additional features

- Smooth joint/connection between bottom, side panels and top.
- Marine Light 220 V, AC and sight glass in certain section for easy inspection.
- All joints shall be sealed with silicon rubber & TB-2 Thermal Bridge. Keeping in viewthe energy conservation system.
- Air tight dampers.

Air handling units shall be supplied factory assembled. The Air Handlers shall be low pressure or high-pressure single zone draw through type as indicated on be equipment schedule.

The Units shall be complete with Coil section with cooling/heating coils, blower section with Centrifugal Blower, pulleys, V belts/Plug Fan with VFD and Electric Motor, Pre-filter section with Pre-filters 50mm panel filters class EU3, Access Doors where ever required, Volume Dampers+ Spring Return Actuator, with flexible connections at inlet, stainless steel drain pan and any other appurtenances necessary for satisfactory operation including incline d tube manometers across filters.

The manufacturer shall demonstrate a continuous period of manufacture and development for at least10 years.

The air handling unit shall be supported by the manufacturer and/or its representative who will provide full technical support, spares holding and trouble shooting capability. A training courseshall be provided by the manufacturer to the consultant / contractor / maintenance engineers.

The Air Handing Unit shall be installed in the following sequence:

- Mixing Box with Flexible connection with Volume Control Dampers for Fresh Air,Supply Air and Return Air.
- Pre- Filter Section with Panel Filters Class EU-3, preferably Aluminum washable typePanel Filters 50mm thick.
- Coil Section with Cooling/Heating coils with stainless steel drain pan.

- Blower section with Centrifugal Blower, pulleys, belts/Plug Fan+VFD and ElectricMotor.
- Any empty section in between the above sections required as supplied by themanufacturer.

**a. Casing**

The casing and frame construction shall be suitable for working pressure up-to (2000 Pa) 8 in of water column. Frame sections, corners connections shall be fabricated with extruded aluminum. Wall, doors & panel covers shall be of double skin design injected with polyurethane insulation of density up to 45 kg/m3 and thickness of 50mm. The casing shall be of pre painted galvanized sheet steel not less than 18 SWG with removable access panels for servicing, hinged, and latched doors for changing filters. The rubber gasket between joints will be provided to ensure leak proof structure. The casing panel Insulation shall meet smoke generation and flame spread requirements of NFPA bulletin 90.

| AHU Size | Measured value/ Limit/ Class |
|---|---|
| Thermal transmittance | 0,83 / 0,5 < U < 1 W/(m²K) (T2) |
| Thermal bridging | 0,62 / 0,6 < kb < 0,75 (TB2) |
| Casing Leakage | 0,08 / 0,63 l/(sm²) (B) |
| Filter Bypass Leakage | <0,1 / 0,5% (F9) Casing |
| Strength | 10 / 10 mm/m (1A) |
| Thermal transmittance | Thermal loss of whole AHU casing. Thermal |
| bridging | Factor shows tendency of condensation of AHU. |
| Casing air leakage | Measured with a pressure of +700 Pa and –400 Pa.Filter- |
| Bypass leakage | Measured with a pressure of +/- 400 Pa. |

**Casing strength**

Deflection of casing with a pressure of +/-1500 Pa. No permanent deformation with pressureof +/-2500 Pa.

**Sound Insertion Loss**

De in accordance with DIN EN 1886 measured at a complete casingRW in accordance with DIN 52210 values of the Thermo Panel only

**Casing Accessories**
**Damper**

With profiles fins and aluminum gearwheel transmission. High air tightness by rubber seals.Leakage class according to DIN EN 1751 (q.v. 'Technical Data').

**Flexible connection**

Coupling made of elastic polyester woven material with PVC coating, with potential equalization (q.v. accessory 'Technical Data').

**Sound insulated connection**

Sound insulated connection with double-U-shaped frame 100x30x3mm, intercostals microcellular Microlen-PE30 and profile rubber sheet and with screw expansion joint, airtight screwing with potential equalization (q.v. accessory 'Technical Data')

**b. Panel Casing:**

The Panels shall be double skinned, minimum 40mm or 50mm thick, made of externalgalvanized sheet steel and inside stainless steel sheet, smooth surface, with insulation, material class A-1, non-combustible type, in accordance with DIN 4120.

The heat insulation value of the panels shall not exceed 0.84 Wm2/K for 40mm panel. The sound transmission loss shall be according to DIN 52210 and 35dB pressure level at 250 Hz shall not exceed 70 dB(A) at the suction side, 80 dB (A) at the discharge side and 50 dB(A) at one meter distance at the side of the unit.

**c. Cooling Coils Section**

The coils shall be combination cooling heating type, mechanically bonded seamless copper tubes expanded into aluminum fines. The fin distance should not be less than 2.5 mm between fine. The casing shall be of Galvanized steel. The tubes shall be correctly circulated for desired velocity of water and the pressure drop across the coil should not exceed 30 kPa. Water flow shall be counter to airflow. Coil header and U-bends shall not be exposed. The coil shall be removable type for easy cleaning. Each coil shall be suitable for working pressure of 14 Bars and 100C. The Air velocity across the AHU coil at the designed Air Volume shallnot exceed 2.5 meter per second.

The computer coil selection report will be submitted for approval.

**d. Drain Pan**

Condensate drain pan should be double skinned fabricated of heavy zinc coated, internally andexternally with two coats bitumastic paint sheet and shall have min 25 mm thickness of injected and expanded polyurethane with vapor sealed insulation elastomer or equal (also meetingNFPA 90A) and inner pan should be coated with corrosion resistant material, situated beneath the cooling coils and arranged so that all moisture will collect in and drain from the pan.

Within raised floor all insulated shall comply with local Authorities requirements.

**e. Fan Section**

Fan will be forward/backward curved blade type in accordance with AHRI Standard 430-78 with self-aligning ball bearings equipped with grease lines extended to fittings outside the casing on the drive side. Fan wheel and shaft will be designed for continuous operation at the maximum rated fan speed than 25% below the first critical speed. Wheel and shaft should be balanced statically and dynamically as one unit. Balanced to Class 1 vibration range.

Each fan shall be driven dual by low maintenance belts of non abrasion material V-belt drive shall be adjustable speed type with variable pitch pulleys for ± 10% of design rotation. The removable belt drive guard will be provided for protection from moving parts with provision for speed measurement of both the fan and motor shafts.

The fan motor shall be selected for maximum energy efficiency. It should be three phase, AC current, squirrel cage motor with adjustable slide base and belt tensioning device manufactured. Motor shall be of the open drip proof type having built in thermal overload protection, not less than 4-pole design with adjustable base. Fan bearings shall not be less than 200,000 operating hours at design operating conditions

Fan and motor will be mounted on a common steel base frame. To prevent the vibration transmission, spring isolators will be provided under the frame and flexible rubberized connection will be provided between fan scroll and casing.

**f. Filters Section with Filter Holding Frame**

The efficiencies and combination of filters section shall be as per equipment schedule. For each filter bank, a differential pressure gauge shall be provided to check filter status.

Pre-Filters will be washable oil dip panel filters having 45% efficiency as per Dust Arrestance Testing standard 52-76 of ASHRAE. The filter media will be aluminum mesh fiber with rigid galvanized steel frame.

**g. Variable-frequency converter/drive**

For continuously variable speed regulation with square torque curve, mounted outside on the ventilation appliance and completely wired to the motor and the maintenance switch using shielded leads (EMC compatible). In the case of weatherproof devices, the variable-frequency converter is internally built in cooled by the air flow and the user interface (display) is separately accessible via an exterior appliance door.

Spurious emissions and harmonics into other electronic facilities and the supply network are minimized through built-in start reactor chokes and radio interference filters, the short and shielded motor leads as well as the installation in the fan section area that is insensitive to disturbances. This ensures compliance with the radio suppression classes A (productionenvironment) and B (residential buildings, trade and commerce) acc. to EN 50081-1, 50081-2, 61800-3.

Devices and installation was type-tested acc. to EMC guidelines following EN 61000-6-1, EN61000-2, EN 61000-6-4, 61000-6

Parametrizing level for various applications such as follows,

- Speed control
- Volume flow regulation (PID)
- System pressure regulation (PID)
- External variable set point selection continuous, (0(4)…20 mA)) or
- External binary (fixed) set-point assignment through potential-free control
- Open protocols such as MODBUS RTU for accessability of Building automationsystem (BAS) or SCADA

The variable-frequency converter was factory parameterized and functionally checked for thespecific fan and motor data. A maximum of operational reliability is guaranteed through presetting of the maximum speed and current limit by the manufacturer.
Protection class: IP 55 or higher

**h. Maintenance switch**

Capable of all-pole, main circuit side switching-off the motor under load. In addition, at least 1 auxiliary floating NO contact for status signal to the DDC (direct digital control), GLT (Central Building Management control systems) provided. Lockable in ¯OFF‖ position through safety lock. Adequately dimensioned conductor sizes and jumpering compartment for connections to be provided by the customer. Mounted outside on the fan housing and wired to the prime mover using flexible leads. In combination with a variable-frequency converter, the maintenance switch has to be placed at the input side of the variable-frequency converter for electromagnetic compatibility (EMC) reasons. 3-pole, 6-pole or 9-pole depending on connection arrangement Protection class: IP-55

### 3. Factory Performance Test

Air Handling Units shall be factory performance tested by the manufacturer as per design conditioned as per procedure given in AHRI/Eurovent standard at specified loads conditions. The documented factory test report shall submit us through mail and shipping documents

## 4. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to these sections:

| | |
|---|---|
| BS 848 | Fans Performance Tests |
| BS 5141 | Air Heating And Cooling Coils |
| BS5285 | Ventilation Fan And Regulators |
| BS 5384 | Control System for HVAC installation |
| CP 3 | Sound and thermal insulation |
| ASHRAE | American Society of Heating Refrigeration Air ConditioningEngineers |
| ASHRAE | Standard 90.1: Energy Code for building |
| ASHRAE | Standard 62: Ventilation for Acceptable Indoor Air Quality |
| ASHRAE | Standard 15: Safety Code for Mechanical Refrigeration |
| NFPA | National Fire Protection Association Standard 99 |
| ASTM | American Society of Testing & Materials. |
| IEC | International Electro technical Commission |
| SMACNA | Sheet Metal Air Conditioning Contractors' National Association |

Equivalent to mentioned codes and standards may be approved by the Consultant on theprovision of evidence of equivalent by the contractor

## 5. SPARE PARTS

Furnish the following spares as recommended by the manufacturer.

| | | |
|---|---|---|
| 1 | Bearing Set for Motor | 1 Set with each AHU |
| 2 | Blower Bearing and assembly | 1 Set with each AHU. |
| 3 | Motor | 1 Motor with each type of AHU |
| 4 | VFD | 1 VFD each type |

# FAN COIL UNITS

## 1. SCOPE

Supply, Installation testing and commissioning of different types of Fan Coil Units of various capacities as per schedule, drawings, specifications and instructions of Consultant.

## 2. DESCRIPTION

I. The unit should be fabricated of 18 SWG galvanized steel, inner casing of coil section shouldbe lined with not less than 1/2" damp proof coated fiber glass insulation as per NFPA- 90A requirements. Fan and motor assembly shall be easily removable. Concealed models shall have 1" supply duct collars. Exposed models shall have 18 gauge steel-panel acoustically and thermally insulated with 1/2" coated fiber glass insulation as per NFPA-90A requirements. Exposed panels shall be boundarized and finished with a baked Desert Tan Primer, Baked enamel finish of color selected. Exposed units shall have an easily removable front panel double deflection supply grilles and deformed recessed access doors shall be provided in the top panels.

Lowboy mode shall be provided with return air grille stamped into the front panel.

Ceiling of exposed model shall be provided with a removable bottom panel with stamped return air grille and provision for integral filter and supply grilles shall be stamped on front panel.

ii. All heating and cooling coils shall be ARI rated. Coils shall have 1/2" OD copper tubes with aluminum fins, mechanically bonded to the tubes, fitted with automatic vents. Coils shall be factory leak tested at 350 psig. Suitable for working pressures upto 250 psig) Coilconnections shall be 3/8" OD made sweat fittings.

iii. Motor should be 3-speed, tap wound and PSC type with thermal overload protection, bearings shall be of the sleeve type with oil tube and oil reservoirs.

iv. Fans shall be of centrifugal forward-curved type; fan wheels and housings shall be of galvanized steel. Fans wheels shall be statically and dynamically balanced.

v. Each fan coil unit shall be supplied with one set of washable filter 50% eff. as per Dust Arrestance Testing standard 52-76 of ASHRAE.

vi. Insulated drain pan shall be of galvanized steel epoxy painted with flexible insulation over entire surface.

## 3. CONTROL & ACCESSORIES

Following controls and accessories shall also be supplied with the each fan coil unit

i. Digital type Room thermostat (of Approved Model and Make) with fan speed control switch low-medium-high and cool/heat selector switch capable to interface with the BMS.

ii. Isolating valves, balancing valve.

iii. Two ways modulating valves

iv. Automatic air vent.

v. Gauge wells

vi. Filter box with one set of cleanable filter installed and one set as spare.

## 4. SPARE PARTS

Furnish the following spares as recommended by the manufacturer.

| | | |
|---|---|---|
| 1 | Motor | 1 Set with each FCU |
| 2 | Blower Assembly | 2 Sets with each type of FCU. |
| 3 | Two Way Valve Body with Actuator | 1 Set with each type FCU |
| 4 | Thermostat | 1 Set with each type FCU |
| 5 | Air Filter | 1 Set with each FCU |

# SPLIT TYPE AIR CONDITIONING UNITS

## 1. SCOPE

Supply, installation, testing and commissioning of complete Decorative wall mounted and Ducted type Ceiling Suspended split system air conditioning units of capacities as shown in equipment schedule drawings and specified herein and as per instruction of Consultant.

## 2. DESCRIPTION

The complete supply and installation of the split system air conditioning unit included but not limited to factory charged tested and packed indoor evaporative unit, outdoor condensing unit, thermostat, refrigerant piping, control and power wiring with isolators, foundation, hangers, support, etc.

### a. OUTDOOR CONDENSING UNIT

I. The air cooled condensing unit shall be completely factory assembled for one piece shipment and rigging leak. The unit shall be pressure and functionally tested at factory to assure a trouble free startup after installation and shall be covered by a manufacturer's warranty.

II. The frame of condensing unit shall be made of angle iron, with corrosion resistance treatment, to provide rigid support for shipping, rigging and dependable operation.

III. The compressor shall be hermetically sealed reciprocating type mounted on vibration isolators and completely enclosed in compartment to minimize the noise transmission. The compressor shall be dynamically balanced. The compressor shall have complete set of safety suction gas strainer, suction and discharge stop valves, low and high pressure cut out switches, over current relay, compressor thermal protection, self lubrication, oil filter etc., The compressor shall be suitable for operation with Green Gas.

IV. The condenser coils should be constructed of copper tube/aluminum fins, mechanically bonded and draw-through types and has adequate face area to meet specified requirements. All coils and fins shall be protected against the marine environment by applying Acra-Clad (Urethane Acrylic) chemical resistant protective coating.

V. The condenser fan shall be directly driven propeller type. The fan shall draw air from three side and discharge at front.

VI. The condenser fan motor shall be water proof induction type and equipped with an over current relay for safe operation. The bearings shall be non-lubrication type for a maintenance free operation.

### b. INDOOR EVAPORATIVE UNIT

i. The indoor unit shall be Ducted type Ceiling Suspended type with configuration as shown on the drawings/schedule.

ii. The blower shall be of centrifugal type and directly coupled to electric motor suitable to deliver required cfm at low sound level. The blower motor shall have three stages control LOW, MEDIUM & HIGH and shall be mounted on rubber isolator.

iii. The evaporator coils shall be constructed of copper tube/aluminum fins mechanically bonded. The evaporator coil shall be factory leak tested, dehydrated, sealed and supplied with a holding charge at site. The protected plugs should not be removed until final connection of piping to the unit.

iv. The evaporative unit shall be internally wired and factory tested, dehydrated, sealed and supplied at site with holding charges.

v. The remote control shall be provided with selector, on-off switch, a built in temperature sensor monitor with temperature & speed selector.

### d. REFRIGERANT PIPING

Copper pipes conforming to ASTM standard B88 type L & M with brazing joints shall be used for the refrigerant (gas + liquid) lines. Both pipes shall be separately insulated with 10mm thick slip-on expanded foam rubber insulation having the thermal conductance of 0.04 W/m.k.

The indoor insulation shall be covered with PVC self-adhesive finishing tape with 20% overlap. The insulation exposed to the weather shall be further protected with the covering of 26 SWG Aluminum cladding.

The entry points of the refrigerant pipes to the building shall be completely water tight so that rain water should not be entered in the building.

### e. CONDENSATE DRAIN PIPE

UPVC Sch. 40 pipes with solvent cement joints shall be used for condensate drain from the evaporative unit. Near to the drain tray, an U- trap with min. 50 mm. water seal shall be installed. The entire length of the drain pipe shall be covered with 10mm thick slip-on expanded foam rubber insulation having the thermal conductance of 0.04 W/m. K.

The indoor-insulated drainpipe shall be covered with PVC self-adhesive finishing tape with 20% overlap. The insulation exposed to the weather shall be further protected with the covering of 26 SWG Aluminum cladding.

The exit points of the insulated drain pipes from the building shall be completely water tight so that rain water should not be entered in the building.

## 3. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to these sections:BS

| | |
|---|---|
| 5491 | Rating and testing of unit air conditioner |
| BS 5285 | Ventilation fan |
| BD 5384 | Control system for HVAC installationCP |
| 3 | Sound and thermal installation |
| ASHRAE | American Society of Heating Refrigeration Air Conditioning EngineersARI American Refrigeration Institute |

Equivalent to mentioned codes and standards may be approved by the Engineer on theprovision of evidence of equivalent by the contractor.

# MULTI DIGITAL VARIABLE REFRIGERENT VOLUME AIR CONDITIONINGUNITS

## 1. SCOPE

Supply, installation, testing and commissioning of complete split system air conditioning unitsand multi digital variable refrigerant volume air conditioning system of capacities as shown in equipment schedule drawings and specified herein and as per instruction of Consultant.

## 2. DESCRIPTION

The complete supply and installation of the split system air conditioning unit included but not limited to factory charged tested and packed indoor evaporative unit, outdoor condensing unit, thermostat, refrigerant piping, control and power wiring with isolators, foundation, hangers, support, etc.

### a. OUTDOOR CONDENSING UNIT

I. The air cooled condensing unit shall be completely factory assembled for one piece shipment and rigging leak. The unit shall be pressure and functionally tested at factory to assure a trouble free startup after installation and shall be covered by a manufacturer's warranty.

II. The frame of condensing unit shall be made of angle iron, with corrosion resistance treatment, to provide rigid support for shipping, rigging and dependable operation.

III. The compressor shall be hermetically sealed reciprocating type mounted on vibration isolators and completely enclosed in compartment to minimize the noise transmission. The compressor shall be dynamically balanced. The compressor shall have complete set of safety suction gas strainer, suction and discharge stop valves, low and high pressure cut out switches, over current relay, compressor thermal protection, self lubrication, oil filter etc., The compressor shall be suitable for operation with Green Gas, R-410/R407.

IV. The condenser coils should be constructed of copper tube/aluminum fins, mechanically bonded and draw-through types and has adequate face area to meet specified requirements. All coils and fins shall be protected against the marine environment by applying Acra-Clad (Urethane Acrylic) chemical resistant protective coating.

V. The condenser fan shall be directly driven propeller type. The fan shall draw air from three side and discharge at front.

VI. The condenser fan motor shall be water proof induction type and equipped with an over current relay for safe operation. The bearings shall be non-lubrication type for a maintenance free operation.

### b. INDOOR EVAPORATIVE UNIT

I. The indoor unit shall be Ducted type Ceiling Suspended type with configuration as shown on the drawings/schedule.

II. The blower shall be of centrifugal type and directly coupled to electric motor suitable to deliver required Cfm at low sound level. The blower motor shall have three stages control LOW, MEDIUM & HIGH and shall be mounted on rubber isolator.

III. The evaporator coils shall be constructed of copper tube/aluminum fins mechanically bonded. The evaporator coil shall be factory leak tested, dehydrated, sealed and supplied with a holding charge at site. The protected plugs should not be removed until final connection of piping to the unit.

IV. The evaporative unit shall be internally wired and factory tested, dehydrated, sealed and supplied at site with holding charges.

V. The remote control shall be provided with selector, on-off switch, a built in temperature sensor monitor with temperature & speed selector.

### c. REFRIGERANT PIPING

I. Copper pipes conforming to ASTM standard B88 type L & M with brazing joints shall be used for the refrigerant (gas + liquid) lines. Both pipes shall be separately insulated with 10mm thick slip-on expanded foam rubber insulation having the thermal conductance of 0.04 W/m.k.

II. The indoor insulation shall be covered with PVC self-adhesive finishing tape with 20% overlap. The insulation exposed to the weather shall be further protected with the covering of 26 SWG Aluminum cladding.

The entry points of the refrigerant pipes to the building shall be completely water tight sothat rain water should not be entered in the building.

### d. CONDENSATE DRAIN PIPE

I. UPVC Sch. 40 pipes with solvent cement joints shall be used for condensate drain from the evaporative unit. Near to the drain tray, an U- trap with min. 50 mm. water seal shall be installed. The entire length of the drain pipe shall be covered with 10mm thick slip-on expanded foam rubber insulation having the thermal conductance of 0.04 W/m. K.

II. The indoor-insulated drainpipe shall be covered with PVC self-adhesive finishing tape with 20% overlap. The insulation exposed to the weather shall be further protected with the covering of 26 SWG Aluminum cladding.

III. The exit points of the insulated drain pipes from the building shall be completely water tight so that rain water should not be entered in the building.

## 3. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to these sections:BS

| | |
|---|---|
| 5491 | Rating and testing of unit air conditioner |
| BS 5285 | Ventilation fan |
| BD 5384 | Control system for HVAC installationCP |
| 3 | Sound and thermal installation |
| ASHRAE | American Society of Heating Refrigeration Air Conditioning EngineersARI American Refrigeration Institute |

Equivalent to mentioned codes and standards may be approved by the Engineer on theprovision of evidence of equivalent by the contractor.

# PUMP SET

## 1. SCOPE

Supply, Installation, Rigging, Lifting, fixing, Placement, Testing and Commissioning of pump sets as shown on drawings and specified herein & as per instruction of Consultant.

## 2. CENTRIFUGAL HORIZOTAL PUMP

The centrifugal horizontal water pump-set shall be end suction, horizontal, split casing complete with pump, flexible coupling, frame, CC foundation, starters, suitable electric motor, discharged and suction connection with valves and accessories as per typical connections of pumps for specified application confirming the pump curves certifying pump operation, BHP & NPSH curves shall be submitted to the consultant for approval.
Pump and driver shall be from approved make.

I. The pumps shall be suitable for quite and continuous operation at actual head and discharge, the pumps shall be single stage, horizontal split case non-loading, cast iron body,volute type.

II. The casing and bearing housing shall be of cast iron, highest point in the casing should be provided with air vent and lowest point should be provided with drain plug.

III. The shaft seals shall be mechanical seal type.

IV. The impeller guide, glands, stuffing box ring, and shaft sleeve shall be of stainless steel.

V. The shaft shall be of stainless steel, turned and ground.

VI. The bearing frame assembly of the pump should be fitted with re-greasable ball bearing equivalent to electric motor's bearing standard.

VII. The pump and motor shall be mounted on a common base plate of heavy structural steel through flexible coupling equipped with a suitable coupling guard.

VIII. The pump casing shall be designed to withstand a discharge head specified plus the static head on system plus 50% of total head, but not less 125 psi.

IX. The electric motors shall be drip proof type provided with suitable starters and totally enclosed, fan cooled type with class "F" insulation and overload protection as per IP54 standards.

X. The pump shall be non-overloading at any point on the characteristic curve.

XI. The flexible connections shall be provided on suction and discharge of the pumps.

## 3. IN LINE WATER CIRCULATION PUMP (VERTICAL)

i The centrifugal vertical in-line water pump-set shall be complete with pump, frame, starters, suitable electric motor, discharged and suction connection with valves and accessories as per typical connections of pumps shown on drawings.

ii. The pump shall be suitable for quite and continuous operation at actual head and discharge,the pumps shall be single/multi stage, non-loading, cast iron body, volute type.

iii. The casing and bearing housing shall be of cast iron.

iv. The shaft seals shall be mechanical seal type and shaft-sealing faces are made of tungstencarbide.

v. The impeller guide, glands, stuffing box ring, and shaft sleeve shall be of stainless steel.

vi. The shaft shall be of stainless steel, turned and ground.

vii. The bearing frame assembly of the pump should be fitted with permanent type ball bearing equivalent to electric motor's bearing standard.

viii. The pump casing shall be designed to withstand a discharge head specified plus the statichead on system plus 50% of total head, but not less 125 Bars.

ix. The electric motors shall be drip proof type provided with suitable starters and totally enclosed,fan cooled type with class "F" insulation and overload protection as per IP54 standards.

x. The pump shall be non-overloading at any point on the characteristic curve.

xi. The flexible connections shall be provided on suction and discharge of the pumps.

### c. SUBMERSIBLE PUMP FOR SUMP

The submersible pumps shall be comprising of followings.

i. Motor housing, suction cover and all screw shall be of stainless steel.

ii. Shaft shall be made of stainless steel with heat treatment for long continuous running withdouble mechanical seal in oil chamber.

iii. Motor shall be built with overload protection.

iv. The impeller shall have non-clog design.

v. Functions selector switch for control of manual-off- Auto shall be incorporated with floatswitch.

## 4. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections:

| | |
|---|---|
| BS 1394 | Water circulator |
| BS 3454 | Electric Pumps |
| BS 5257 | Horizontal End Pumps |
| DIN 2944 | Pump Curves |
| ASTM | American Society of Testing & Materials |

Equivalent to mentioned codes and standards may be approved by the Consultant on the provision of evidence of equivalent by the contractor.

PLANNING ENGG. ARCHITECTURAL & SERVICES CONSULTANT ESS.I.AAR 314, Masbriq Centre S.S Suleman Road, Karathi

STATE BANK OF PAKISTAN PROJECT MANAGEMENT DIVISION ENGINEERING DEPARTMENT SBP BSC HOK

# FANS, BLOWERS AND EXTRACTORS

## 1. SCOPE

Supply, installation, testing & commissioning of Exhaust Air & Fresh Air fans complete in all respects of various capacities as shown in schedule of fan, drawings, specified herein, & as per instruction of Consultant.

Motor shall confirm to specification under motor and shall be sized to provide the required BHP for meeting the specified conditions without overloading.

## 2. DESCRIPTION

The fans and blowers used for exhaust and ventilation shall be complete with electric motor efficiency IE3, starter, frame, weather proof accessible enclosure and etc. In this section word fan and blower shall be used with the same meanings.

2.1 The fan/blower shall be statically and dynamically balanced and factory tested. The vibration of fan shall not be transmitted to building structure and damped by suitable vibration isolators.

2.2 The belt driven fan shall be supplied with belt guard and variable pitch pulley for adjusting the fan speed ± 10% of the design speed.

2.3 Fan housing shall be of heavy gauge mild steel, continuously welded construction with rigid reinforcement on anti-vibration support on spring mounting. All fan housing shall beequipped with flanges discharge & removable spun inlet canvas designed for smooth airflow.

2.4 Fan wheel shall be rigidly constructed accurately balanced both statically & dynamically onprecision electronic equipment & shall be free from objectionable noise and vibration.

2.5 Fan shall have shafts of solid hot rolled stainless steel accurately turned, ground, polished & ring guard for accuracy. Close tolerances must be maintained where the shaft makes contract with the bearing.

2.6 Fan shall have heavy duty, permanently lubricated, self aligning, pillow block type bearing, selected for min avg. bearing life of 125000 hrs.

2.7 Fan & motor drive shall be mounted on heavy steel framing. Motor shall be mounted on slide rail. Fan shall be with variable pulley & suitable for adjustment with in ± 10% of specified RPM, provide complete belt guard on fan and motor pulley constructed of heavysteel framing & expanded metal mesh screening.

2.8 Self closing gravity louvers, bird mesh and rain protection hood shall be pr for the exhaust and ventilation fans, located outside the building.

2.9 Heavy duty, air tight canvas connection shall be provided for fans installed with ducts.

2.10 The propeller fans shall be direct-driven types with totally enclosed weather proof electric motors.

2.11 The roof extractor/ventilators shall be of the centrifugal belt driven type with backward inclined fan blades, a weather tight housing for motor constructed of aluminum, galvanized steel, or glass fibber reinforced high-impact plastic. Fan discharge opening shall be provided with (1/2" x 1/2") wire mesh bird screens suitable for the weather tight housings. Sealed permanently lubricated sleeve, roller or ball bearing with provision for end thrust, shall be provided. Drip proof electric motor shall be provided with safety disconnect switch mounted under the fan housing adjacent to the motor. Motor and rotating parts shall be mounted on isolators of neoprene or other approved materials. Capacities shall be as shown on the drawings.

2.12 The range hood exhaust fan unit shall be of the roof mounted, centrifugal up-blast type, complete with weather tight housing for mounting on a curbed opening, adjustable V-belt drive, motor and vibration isolators. Housing shall be of spun aluminum, designed to discharge air vertically upward and to prevent entry of snow or rain into the building. Fan Wheel shall be of aluminum with backward inclined blades. Motor shall be of the ball bearing, drip- proof type. Motor and drive shall be mounted outside the air stream and cooled by outside air entering through a tube. Unit shall be prewired at factory with a junction box for field connections and a safety disconnect switch mounted inside the cover. Capacities shall be as shown on the drawings. Unit shall be rating in accordance with AMCA Standard 210, or other approved standard.

2.13 The air curtain fans shall be of the cabinet enclosed, direct connected centrifugal fan type, designed for mounted above the ceiling, complete with fans, motor, cabinet, supply air diffuser and ceiling grill. Motors shall be single speed or two speed as shown on the drawings and capacities shall be as indicated.

2.14 Ventilation fans shall be wall mounted propeller fan complete with fan, motor, wall mounting plate mounting bracket, safety guard grill and speed regulator, blades and hub shall be aluminum die coasted, contoured to streamline air flow and produce low noise. Blades and hub shall be natural finish anodized after caster. Motor shall be single phase, 720 Rpm, psc type for 50 Hz. Fan motor assembly shall be mounted on a rotating base to divert air flow.

## 3. ELECTRICAL WORKS

Unit shall be pre-vired at factory including weatherproof isolator box with isolator switch. Unit shall be properly grounded with building earthing system.

## 4. PAINT WORK

Each component shall be thoroughly degreased, phosphatised and provided with two coats ofspecial anti rust primer & two coats of rubber chlorinated paint.

## 5. FRESH AIR LOUVER FOR FRESH AIR FAN

Supply & install where indicated / shown on drawing or specified herein M.S intake louvers. The blade & frame shall be of heavy gauge M.S. sections provided with powder coating as approvedby Consultant. The blade of louvers shall be set at 45°. The louvers shall be provided with bird mesh, so installed as to be removable for cleaning & replacement of mesh.

## 6. FILTER & FILTER SECTION FOR FRESH AIR

Provide filter section with pre filter & main filter, complete in all respect. Pre filter shall be of 45° dust arr. 2 in aluminum make & main filter shall be of synthetic fibre pleated type, washable with 90% dust arr. The filters shall be selected for face velocity not exceeding 550 Fpm (3.0 m/s.) The initial pressure drop shall not be greater than 25 Pa. of water.

Filter section shall be fabricated in 16 gauge M.S. sheet metal & shall be suitable to remove & re-install filters easily.

## 7. TESTING & COMMISSIONING

Fan & its accessories shall be commissioned, tested & balanced by contractor. Before fabrication contractor shall submit the shop drawing showing the fabrication detail & TechnicalSpecification of Fan & its accessories. No Fan shall be fabricated & delivered at site without Consultant approval.

## 8. SPARE PARTS

Furnish the following spares as recommended by the manufacturer.

| | | |
|---|---|---|
| 1 | Bearing Set for Motor | 1 Set with each Fan |
| 2 | Blower Bearing and assembly | 1 Set with each Fan. |
| 3 | Fan Belt | 2 Sets with each Fan. |
| 4 | Motor | 1 Motor with each type of Fan |

# SMOKE EXTRACTOR

## 1. SCOPE

Supply, installation, testing & commissioning of AMCA Approved and Certified Explosion Proof, accordance ATEX guideline 94/9, Fire Resistant, Backward curved wheel Centrifugal Fan, Ducted Axial fans complete in all respects of mentioned capacities as shown in schedule of fan, drawings, specified herein, & as per instruction of Consultant.

Motor shall confirm to specification under motor and shall be sized to provide the required BHPfor meeting the specified conditions without overloading.

## 2. DESCRIPTION

The fans and blowers used for exhaust and ventilation shall be completed with electric motor efficiency class IE3, starter, frame, weather proof accessible enclosure and etc. In this section word fan and blower shall be used with the same meanings.

Suitable to convey clean/dusty air up to a temperature of 600 Deg C for 2h and the evacuation of high temperature smoke and cold smoke; ideal therefore for emergency exhaust in case of fire.

The Fans shall be of forced exhausting allows the placing in depression of the room and preventing the of smoke into other rooms, creating better conditions of escape for the occupants and making the identification of the hotbed easier for the fire man.

2.1 The fan/blower shall be statically and dynamically balanced and factory tested. The vibration of fan shall not be transmitted to building structure and damped by suitable vibration isolators.

2.2 The driven fan shall be direct drive.

2.3 Fan housing shall be of heavy gauge quadrangular frame in galvanized steel, continuously welded construction with rigid reinforcement on anti vibration support on spring mounting. All fan housing shall be equipped with flanges discharge.

2.4 Fan wheel shall be single width backward curved wheel with die-casted aluminum hub, rigidly constructed accurately balanced both statically & dynamically on precision electronic equipment & shall be free from objectionable noise and vibration.

2.5 Fan shall have heavy duty, permanently lubricated, self aligning, pillow block type bearing, selected for min avg. bearing life of 125000 hrs.

2.6 Fan & motor drive shall be mounted on heavy steel framing. Motor shall be direct mounted.

2.7 Self closing gravity louvers, bird mesh and rain protection hood shall be provided for theexhaust and ventilation fans, located outside the building.

2.8 The Propeller fans shall be direct-driven types with totally enclosed weather proof electric motors. The casing in galvanized steel sheet, with fixing flanges manufactured according to UNIISO 6580-EUROVENT ½ Standard, protected against the atmospheric, fire resistant paint.

2.9 The roof extractor/ventilators shall be of the centrifugal direct driven type with backward inclined fan blades, a weather tight housing for motor constructed of aluminum, galvanized steel. Fan discharge opening shall be provided with (1/2" x 1/2") wire mesh bird screens suitable for the weather tight housings. Sealed permanently lubricated sleeve, roller or ball bearing with provision for end thrust, shall be provided. Drip proof electric motor shall be provided with safety disconnect switch mounted under the fan housing adjacent to the motor. Motor and rotating parts shall be mounted on isolators of neoprene or other approved materials. Capacities shall be as shown on the drawings.

2.10 The Fans Motors shall be of three phase asynchronous motor single speed or two speed according to international standards IEC 34-IEC 72 and 89/392 EEC -89/336 EEC 73/23 EEC and marked CE, IP65, class F, as shown on the drawings and capacities shall be as indicated.

## 3. ELECTRICAL WORKS

Unit shall be pre-wired at factory including weather proof isolator box with isolator switch. Unit shall be properly grounded with separate earthing system.

## 6. TESTING & COMMISSIONING

Fan & its accessories shall be commissioned, tested & balanced by contractor. Before fabrication contractor shall submit the shop drawing showing the fabrication detail & Technical Specification of Fan & its accessories. No Fan shall be fabricated & delivered at site without Consultant approval.

## 7. SPARE PARTS

Furnish the following spares as recommended by the manufacturer.

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Karachi

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ENGINEERING DEPARTMENT SBP BSC HOK

# G.I SHEET METAL DUCT WORK

## 1. SCOPE

Supply, fabrication, installation and testing of G.I. sheet metal confirming to comply ASTM A527, for ductwork lock forming with minimum coating of 1.25 ounces per square foot and shall conform to specifications for zinc-coated galvanized steel sheets meeting the requirementsof I.M.C. Standard No. 2-2. All ductwork shall be fabricated and installed in full compliance with International Mechanical Code, and as specified hereinafter or as detailed in the drawings complete in all respects with accessories for Ventilation systems as per drawings,specified herein and instructed by the Consultant.

## 2. QUALITY ASSURANCE REQUIRMENTS

2.1 Ductwork to be exposed in occupied spaces shall be free from visual imperfections, including pitting, seam marks, roller marks, stains, discolorations and other imperfections, including those which would impair painting. Where indicated on drawings, provide stainless steel duct complying with ASTM AS167 with No.4 finish. Protect finished surface with mil applied adhesive protection paper, maintained throughfabrication and installation.

2.2 Thickness of metal for air ducts and duct support requirements shall comply with schedules as indicated hereinafter. The partitions and the ceilings forming all plenums, housing and connections for air intakes, the filters, etc., and other portions of the ductwork where so noted on the drawings shall be made with eighteen (18) gauge, G.I.,with standing lock seams. They shall be fitted with 1-1/2" x 1-1/2" x 3/16" stiffening angles on all sides of the housing spaced a minimum thirty-four inches (34") center to center being located between the seams.

2.3 The specification and installation of all ventilation and air-conditioning ducts and fittings, and all materials (incl. ventilation ducts, sealant, insulating materials, binders, flexible joint rings, adhesive, fiber glass panels) used shall comply, as a minimum, with related applicable with current SMACNA, BS, EN and ASHREA standards (or with GB standards) and CIBSE design guide.

2.4 Take-offs from main and branch ducts, unless otherwise noted on the drawings, shall bemade with either spin-in connectors or forty-five degree (45°F) taps and provided with volume dampers. All panels shall be either cross broken or beaded 12" on center to ensure rigidity. The internal ends of all slip joints shall be installed in the direction of flow.All braces, stiffeners and hangers shall be placed outside of the ducts. All longitudinal duct, seams and transverse joints shall comply with the International Mechanical Code Sections as listed hereinbefore except that all exposed duct located in occupied areas shall have transverse joints made with "DUCTMATE" system.

2.5 All changes in direction of the ducts shall be made possible with inside radius not lessthan one and one-half (1-1/2) times the width of the duct. Where, due to space limitations, it is necessary to use elbows of less radius; or where indicated on the drawings, elbows having turning vanes shall be used. These turning vanes shall be as hereinafterspecified.

2.6 All ducts shall be installed true to line and grade. All concealed horizontal ducts shall beinstalled to leave the greatest possible furring space under them, or as indicated on thedrawings. Where necessary, changes of elevation in the ducts shall be made to secure this result, but not without acceptance of the Architect.

2.7 Changes in the shape of the ducts shall be made at small angles. Sides of the ducts shall diverge or converge at an angle not greater than thirty degrees (30°F).

2.8 Where required, sheet metal connections shall be made to building structure by means of

galvanized angles anchored to the structure and the sheet metal bolted to the angles.

2.9 All galvanized round duct shall be of spiral lockseam construction. Where indicated on drawings, all plenums shall be constructed of twenty (20) gauge.

2.9.1 Round Duct and Fittings: Round and oval ductwork where indicated on drawings shall bespiral lock seam low pressure type and shall be constructed of galvanized steel meeting ASTM-A-527 requirements. Round duct shall be of gauge thickness as indicated on schedule and all fittings shall be minimum 22 gauge. Reducers shall be formed type. Ninety degree (90°F) elbows shall be four (4) piece type. Forty-five degree (45°F) elbowsshall be three (3) piece type. Fittings shall have seams and joints spot welded and sealed airtight with duct sealant. All circumferential joints shall be duct to duct couplings, mechanically fastened with sheet metal screws, minimum four (4) per fitting and not to exceed twelve inches (12") on centers.

2.10 Flexible Duct and Fittings: (Above furred ceilings only) Flexible ductwork between sheet metal ducts and air outlets shall not exceed 6'-0" in length and shall be FAM Type AC-6,or Thermo-Flex G-KM, factory fabricated assembly consisting of a galvanized spring steelwire helix covered with a continuous, non-perforated interior air seal liner and wrapped with a one inch (1") barrier jacket, factory sealed at both ends of each section. The flexible duct shall conform to the requirements of NFPA Bulletin No. 90A and shall be labeled by Underwriters' Laboratories, Inc., as a Class I air duct. Installation shall have aflame spread if not more then 25 and a smoke density not exceeding 50. Flexible ductwork takeoffs from main and branch ducts shall be made with a sheet metal pressure tap-in, Glass Insulation Company SM-IDEL combination unit, having adjustable damper and extractor hardware. Connections to sheet metal collars shall be with high pressure duct sealer applied to the interior of the flexible duct for a minimum of three inches (3") and secured in place over the collar with one-half inch (1/2") wide positive locking steel orvinyl straps.

2.11 All ventilation and air-conditioning ducts and fittings delivered to the site must be brand new products complete with erasable label to identify the different grades, materials and manufacturers.

2.12 During transit and storage and installation, correct protective measures shall be taken so that the ventilation and air-conditioning ducts and fittings are not subject to damage and corrosion in any condition.

2.13 Before defining the manufacturer for materials and parts, provide samples to the owner/consultants for approval before manufacturing strictly to the samples.

2.13 Ducts must be made from non-combustible materials and the insulation and silencing materials and adhesives for the ducts must be non-combustible or fire-retardant.

2.14 The manufacturer for ventilation and air-conditioning ducts and fittings shall provide technical instructions and training for the installation.

## 3 SUBMITTAL FOR APPROVAL

3.1 Within 2 weeks after defining the subcontractors and before placing formal orders or fabrication at site/factory, the following documents have to be submitted for approval.

3.2 The contractor shall obtain the approval and perform necessary inspections to the specified construction codes and standards involved in the system used, and provide the owner with the written documents required expressly by the acceptance, inspections and codes before the execution on site.

3.3 The manufacturer shall submit the details for connection of related ventilation and air-conditioning ducts and fittings for approval.

3.4 The installation, operation and maintenance manual developed by the manufacturer shall give detailed description of the procedures and rules for installation, operation and maintenance.

3.5 If required, the testing certificate and testing certificating documents from themanufacturer must also be submitted for review.

## 4. DESCRIPTION

### a. DUCT WORK CONSTRUCTION & INSTALLATION STANDARDS

All sheet metal duct work as shown on drawings shall be fabricated from Prime quality, prime finish galvanized steel sheets conforming to ASTM A527, lock-forming quality, uncoiled, regular spangle & having min coating of 275 g/m2.

All duct construction and installation shall be carried out in accordance with current SMACNA BS, EN and ASHREA standards (or with GB standards) and CIBSE design guide. Otherwise indicated her in. In case of fittings other than the standard ones from the manufacturer, approvalmust be obtained before use.

The ventilation and air-conditioning ducts and fittings for the project must be productsfree of asbestos.

Ducts of A/C system and smoke prevention and extraction system shall comply with HVCA DW 144 or equivalent.

The duct sizes shown on the working drawings are net dimensions of internal chamber,and sufficient space must be made available for ducts requiring insulation.

Split multi-blade air volume regulating damper must be mounted on the branches as shown in the working drawings.

Fire dampers must be installed at locations shown on the working drawings. The construction of the fire dampers must meet the requirements of fire control.

For the connection of A/C fans and ventilators, flexible joints with a length of not less than 50mm must be installed at the connections to prevent transmission of vibration.

Flexible joints are also desired at the expansion joints of a building. The materials for flexiblejoints shall be fire proof or fine canvas coated with fire paint on both sides.

All duct joints as specified herein should be completely air tight and made neat and smooth in order to minimize the resistance to air flow. No duct should be constructed of more than 4 ft long section. All duct hangers as specified herein should be firmly fixed with building structure and the great care should be taken in fixing the hanger so that no damage should be occurred to the building structure. Provisions should be made to reinforced the insulation at hanger location so that no damage should be occurred to the insulation.

Generally all elbows should be full radius type, but where there are space limitations existed, short radius elbow should be constructed with approved double width turning vanes.

Generally all takeoffs should be using full radius elbows, but due to space limitation square elbow takeoffs should be constructed with approved double width turning vanes.

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Unless otherwise indicated the net free area of the duct dimension given in the contract drawing shall be maintained. The duct dimension shall be increased as necessary to compensate for liner thickness.

Splitter dampers, quadrant volume control dampers, air defectors, fire door and fire dampers, duct access door and duct test holes shall be installed where shown on the drawings and where required for the proper operation of the system even through not shown on the drawings.

All joints shall be sealed with an approved duct sealant such as Silicon Sealant or approved equivalent. Putty shall not be used.

Ducts passing through walls shall be provided with Deodar Wooden framing ¾‖(20mm) thick & full width of wall.

## b. DUCT WORK SCHEDULE

All ductwork should be fabricated according to the following schedule.

**SCHEDULE OF G.I SHEET METAL DUCT:**

| DUCT DIMENSIONS | MATERIAL GAUGE | TRANSVERSE JOINTS |
|---|---|---|
| Upto 12" | 24 Gage | Drive slip spaced not more than 4ft. |
| 12" - 26" | 24Gage | Standing seam spaced @ 4ft centre. |
| 28" - 52" | 22Gage | Reinforced bar slip spaced @ 4ft centre. |
| 52" - 81" | 20 Gage | Angle iron slip @ 4ft centre. |

All ducts over 18" in either dimensions should be cross broken, except to which rigid insulation applied on area of duct where outlet or duct connection is to be installed. Duct seams should either be Pittsburgh lock seam or lock grooved seam. Longitudinal seam which shall run horizontally on the duct sections are important because these locks must hold the duct pieces securely and tightly and shall not leak under pressure and should be readily and swiftly put together on the job.

## c. DUCT HANGERS.

All hangers supporting duct should be rigidly fixed with building structure by means of expansion bolts or power driven fasteners of selected sizes for various point's loads due to different sizes of ducts. All hangers should generally be spaced at 8ft centers on straight runs of ducts. Hangers should also be provided at each end of all elbows, at the take-off points of all branch ducts and where as required. All hangers should be trapeze types. Trapeze should not be secured to the duct.

**HANGER SIZE SCHEDULE:**

| MAXIMUM DIMENSION. | STEEL ROD SIZE | TRAPEZE SIZE |
|---|---|---|
| Upto 18" | 1/4" dia | 1" x 1" x1/8" |
| 18" - 36" | 3/8" dia | 1-1/2"x1-1/2"x1/8" |
| 36" -100" | 1/2" dia | 2" x 2" x 1/2" |

## d. GALVANIZING

All hangers, angle iron bracing & other iron work shall be hot dip galvanized with one coat of anti rust paint should be applied to the hanger before installation and than one coatafter installation.

## e. DUCT TAPE AND SEALER

**e.1** All longitudinal snap lock joints shall be made airtight with high pressure duct sealant TREMCO J.S. 773, GREY A.F., or Foster 1042 and transverse joints sealed with Hardcast AFG No. 1402 foil grip instant tape sealant for rectangular ducts and round ducts, all U.L. classified with NFPA 90A rating of a flame spread not exceeding 25 and a smoke developed rating not exceeding 50. At contractor's option, all round duct transverse joints may be madewith MIRACLE D-619 water based, duct sealant U.L. classified 309U as manufactured by MIRACLE ADHESIVES CORP. or Foster 32-19. Ductwork exposed in occupied areas shall have transverse joints sealed with Miracle D-619 sealant and all joints wiped clean after application.

**e.2** Exposed outdoor ductwork shall be sealed as described herein and, in addition, all transverse joints shall be covered with Glenkote ¯Seal-Flex‖.

## f. ACCESS DOORS

Access Door shall be provided as per SMACNA Standard, with an approved means of access, large enough to permit inspection, Access doors or access panels should be provided in duct system before and after equipment installed for inspection, operation and maintenance. Access doors should also be provided for access to volume control damper, splitter and fusible links at fire dampers.

All such doors should be of double construction, fabricated of not less than 20 gauge sheet and shall have sponge rubber gasket around the entire perimeter to make them air tight and should be hung on heavy flat hinges and secured in the closed position by means of wing type catches. The doors should be made with inner and outer plates 1-1/2" apart and should be filled in with 1-1/2" thick fibre-glass insulation.

## f. AIR CONTROLS

The flow of air to the branch take-off should be regulated by means of splitter dampers. The position of splitter dampers are shown on the drawings. A straight take-off should be used where a branch has only one outlet and reflector damper (air control grid) should be installed on the collar for better control of air to the take-off.

## g. FIRE DAMPERS

Fire dampers complying with recognized standards shall be installed in accordance with approved manufacturer's installation instructions. Fire dampers shall be curtain type with blades removed from the air stream to allow for maximum free area. Fire dampers shall have been tested for closure under airflow conditions and shall be labeled for both maximumairflow permitted and direction of flow. When more that one damper is installed at a point in a single air path, the entire airflow shall be assumed to be passing through the smallest damper area. Fire dampers shall be labeled by an approved agency. Only fire dampers labeled for use in dynamic systems shall be installed in heating, ventilation and air-conditioning systems which are intended to operate with fans "on" during a fire. Ductwork shall be connected to damper sleeves or assemblies in such a way that collapse of the ductwork will not dislodge the damper or impair its proper operation.

Fire dampers of the following construction should be installed in all the supply duct after air handling unit and where duct crosses the partitions or walls. The construction of fire dampers should be such as to give tight automatic shut-off in case temperature in the duct should exceed 212 degree F. A fire damper is to be held open by a fusible link which shall allow the fire damper to close and lock shut when the temperature exceeds the safe limit. All fire dampers must be mounted with blades and axles in a horizontal position of airflow should always be such as to assist in the gravitational closing of the fire damper. All dampers should be equipped with side stops angles, and end stop angles. All section is tobe marked for correct installation.

Fusible link fire dampers shall be provided in all ducts passing through fire separations in accordance with governing authorities. Fire dampers shall be "Style B" out of airstream. Provide a 12-inch x 12 inch access panel in ductwork six inches (6") from fire damper for resetting the fusible link whenever the damper is inaccessible from grille or register.

Designed and constructed in accordance with NFPA 90A and UL Standard 555

## g. FIRE/SMOKE DAMPER

g.1 Provide fire/smoke dampers for wall and concrete floor of types and sizes required.Construct casing of minimum 16 gauge galvanized steel. Provide 165°F fusible link. Provide stainless steel spring loaded leakage seals in sides of casing and 36 inch wire leads for connecting smoke link to smoke detector. The detector housing shall be equipped with either an ionization or a photo electronic duct detector, sampling tubes and mounting bracket. Minimum, Class II metal to metal smoke leakage, provide shunt motor for units up to 18" x 18" and oil immersed gear train for larger units. Stall motors are not acceptable. Motors shall have a minimum operating temperature of 250°F.

g.2 For corridor ceiling applications, dampers shall be of similar construction to those above except in tunnel corridor construction (where the ceiling construction is similar to that of the wall) provide dampers that have been specifically tested and listed for horizontal mounting as "corridor dampers" under UL 555 and UL 555S. Dampers that are installed in corridor ceilings, where construction is ceiling-floor or ceiling-roof assemblies that require radiation protection will be radiation dampers that have been tested and listed under both UL 555 andUL 555S. The dampers will have a minimum Class II leakage rating. The dampers will be activated by bimetal electric link that responds to a signal from a smoke detector and shall require manual reset.

## h. VOLUME CONTROL DAMPER

h.1 Volume dampers shall be provided and installed on all supply, return and exhaust ducts as indicated on the drawings and as required for proper balancing of the system. Dampers shall be fabricated of same material as duct system served.

h.2 Single blade volume dampers shall be provided in all round ducts and in rectangular ducts not exceeding eight inches (8") in depth. Damper blades shall be constructed of not less than twenty (20) gauge galvanized steel. Dampers shall be complete with galvanized steel frame, blades, control shaft, hand quadrant and bearings.

h.3 Volume dampers provided in ducts exceeding eight inches (8") in depth shall be factory made, opposed action multi-blade type.

## i. BACK DRAFT DAMPER

i.1 General: Provide backdraft dampers of types and sizes required. Construct casings of 0.090 thickness aluminum with mitered corners.

i.2 Blades, 0.025" formed aluminum with extruded vinyl edge seals. Bearings, Zytel. Linkage 1/8" x 1/8" aluminum tie bars concealed in frame.

i.3 Counterbalance: Zinc plated bar on blades (except top blade). Adjustable for final setting. Mill finish.

i.4 Counterbalanced Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-ga aluminum,diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/2" x 16-ga channel for face areas over 25 sq. ft.Provide galvanized steel finish on frame with aluminum touch-up.

i.5 Where indicated on drawings, provide motor operated 2 position dampers.

j. SLEEVES

All dampers shall have 10 gauge steel sleeves. Dampers with maximum dimensions less than 18" are to have a minimum of 2" x 1/8" x 3/16" steel bar frame bearing supports.

k. BLADES

Dampers over 3.5 sq. ft in area are to have corner braces. Dampers over 3 ft in length and 2 ft in height are to have the tie rods 2 ft or less apart. Additional braces of frame or blades are to supplied as required.

l. MOUNTING PROVISIONS

Damper frames are to have holes every 18" or less on all sides of mounting and should be mounted with rigid angle iron frame riveted to duct on both sides.

m. DUCT LEAKAGE TEST

Duct, Plenums and casing shall be tested and made substantially air tight at static pressure indicated for the system before covering with insulation or concealing in the masonry. The term substantially air tight shall be construed to mean that no air leakage is noticeable through the senses of feeling or hearing.

For low Pressure System upto 2‖ wg (500 Pa), all joints shall be sealed with sealant and physically inspected for light penetration from outside to inside. For system operating pressure above 2‖ of wg (500 Pa), smoke test will be performed by connecting a fan to duct system to build up operating pressure, checking for leakage at all joints, which shallbe sealed with silicone sealant and system retested.

All ducting and related airside equipment and accessories for low grain application (40grains-14grains) must be fully sealed with silicone sealant only and made fully airtight.

n. FLEXIBLE CONNECTIONS

All duct connections with air moving unit should be made through rubber impregnated fibreor equally approved material to avoid the transfer of vibration from fans to the duct work.

All ducts shall also have flexible connection adjacent to the building expansion joints to avoid any damage to the duct system.

o. DUCT INSULATION.

All duct work shall have 1" thick 24kg/m3 density fiber glass insulation blankets with thermal

conductivity not exceeding 0.28 at a mean temperature of 76 degree F. Insulation shall have factory applied over the insulation a vapor barrier facing of aluminum foil glass serim kraft.

All duct insulation should be applied over clean and dry surface and all vapor barriers should be properly sealed to prevent moisture penetration. All insulation should be adhered to duct with manufactured approved adhesive applied to duct in 4" wide brush strips on at least 10" centre to centre. Insulation should further be secured with galvanized steel wire with suitable protection at the duct corners to safe guard any damage toinsulation due to steel wire. All insulation joints should be sealed with 3" wider pressure sensitive aluminum foil tape. The duct insulation should be finally covered with colored cloth through approved adhesive and painted anti-algae paint of approved make and color.

The insulation exposed to the atmosphere should be 2" thick and weather protected with 3layers of bituminous felt, properly sealed to avoid penetration of any moisture on the insulation surface. 26 SWG G.I. sheet metal cladding shall be provided to protect the mechanical damage to the duct.

p. **ACOUSTIC LINER**

Minimum 10 ft or more as approved by Consultant section of all the supply air ducts from the fan discharge, shall have 1" thick fibre-glass sound liner having a minimum sound absorption co-efficient of 0.95 at a frequency of 2000 Hz,

q. **AIR PLENUMS**

Supply air and return air plenums should be fabricated and installed as shown on drawings. The gauges of sheet metal should be one size lower as given in ductwork schedule.

r. **SOUND ATTENUATING EQUIPMENT - DUCT SILENCERS**

r.1 Provide factory fabricated duct silencers of tubular or rectangular type, for high or low velocity service, with arrangements, sizes, and capacities as indicated on Drawings. Construct silencers of galvanized steel with casing seams sealed or welded to be airtight at a pressure differential of 8" water gage between inside and outside of unit, and stiffen or brace as necessary to prevent structural failure or deformation at same condition, or audible vibration during normal operation. Use an inert acoustical absorbing filler material or inorganic mineral or fibrous glass that is vermin and moisture proof and will impart no odorto airstream. Filler material shall have fire hazard classification values, when tested in accordance with ASTM E84, NFPA 255, or UL 723, not exceeding following:

r.1.1 Flame Spread: 15
r.1.2 Fuel Contribution: 0
r.1.3 Smoke Development: 0

r.2 Select silencers from acoustical and aerodynamic rating tables based on actual test readings or interpolated values of such readings obtained from tests made by recognized independent laboratories acceptable to the District. Tests shall be in accordance with ASTME477.

r.3 Select silencers for air pressure drops not exceeding those indicated on Drawings, and of types, sizes, and models for which noise reduction values, or dynamic insertion loss, in decibels reference 10-12 watts, are not less than indicated on Drawings.

s. **SMOKE DETECTORS**

s.1 Where indicated and/or required, provide a duct smoke detector UL listed. The detector housing shall be equipped with either an ionization or a photoelectronic duct detector as required, sampling tubes and mounting bracket. For exposed outdoor applications, provide NEMA listed weatherproof covers.

## 5. EXECUTION

### 5.1 EXAMINATION

Examine areas and conditions under which work of this Section will be performed. Correct conditions detrimental to proper and timely completion of work. Do not proceed until unsatisfactory conditions have been corrected.

### 5.2 DUCT WORKS

5.2.1 Ductwork shall be fabricated in accordance with pressure-velocity classification as indicated in Uniform Mechanical Code except that minimum pressure to use is 2‖ of water.

5.2.2 Construct all ductwork using details of fabrication, and methods of support as indicated in the SMACNA Manuals.

5.2.3 Unless otherwise approved, construct ducts to conform accurately to dimensions indicatedand to be straight and smooth on inside, with joints neatly finished.

5.2.4 Anchor ducts to building structural slab, framing and roof decking and detail method of anchoring and fastening if not indicated on Drawings. All supports shall be seismically constructed.

5.2.5 Construct and install ducts so as to be completely free from vibration under all conditions ofoperation.

5.2.6 Indicate on layout drawing, required for suspended ductwork, location of supports, loads imposed on each fastening or anchor.

5.2.7 Attach supports only to building structural framing members and concrete slabs.

5.2.8 Where supports are required between structural framing members, detail and install suitable intermediate metal framing.

5.2.9 Ducts handling air conditioning or heating supply air, shall be insulated in accordance with requirements.

5.2.10 Ferrous angles and structural members and joining collars specified for construction and support of ductwork and plenums, shall be galvanized.

5.2.11 Broken places in galvanized coating shall be acid washed and then completely soldered over or painted with galvanizing paint.

### 5.3 DUCT AND PLENUM WITH LINERS

Ducts shall be lined 15ft up-to blower and plenums lined with acoustical insulation.

### 5.4 DUCT ELBOWS AND TURNING VANES

5.4.1 Duct elbows, including supply, exhaust, and return, shall be made with a centerline radius of 1.5 times duct width parallel to radius whenever possible, and in no case shall centerlineradius be less than width of duct parallel to radius.

5.4.2 Where space does not permit above radius, or where square elbows are indicated on Drawings, turning vanes of an approved type shall be installed whether indicated on Drawings or not.

5.4.3 Turning vanes shall be double wall vane type.

## 5.5 DUCT TRANSITION

Slopes in sides of transition pieces shall be no greater than 1 to 5. No abrupt changes oroffsets of any kind in duct system will be permitted. Radius turns or turning vanes may be used or special approved guiding vanes may be utilized.

## 5.6 DUCT TEST HOLES

Holes in ducts and plenums shall be provided for using pitot or static tubes for taking air measurements to balance or check air systems. Holes shall be covered with a neoprene gasketed sheet metal cover or plugged with a fitted neoprene plug chained to duct.

## 5.7 SOUND ATTENUATING EQUIPMENT

Install sound attenuators where required and indicated on Drawings. Refer to manufacturer's instructions for proper installation.

## 5.8 FIRE AND SMOKE DAMPERS

5.8.1 Fire dampers or combination fire and smoke dampers shall be installed and accessible ateach duct penetration of rated walls and partitions and as required by State Fire MarshallNFPA 90A.

5.8.2 Fire dampers shall be sized and adjoining duct enlarged to assure full size air passage of connecting ductwork.

5.8.3 Install smoke dampers as indicated on Drawings and as required in ducts penetrating smoke isolation separations.

## 6. SMOKE DETECTOR

Smoke detector shall be installed in accordance with requirements of the International current edition.

## 7. PRESSURE TESTING

Test and make substantially airtight supply, return, and exhaust ducts, plenums, and casings, at static pressure indicated for system before covering with insulation or concealing in masonry. Substantially airtight shall be construed to mean that no air leakage is noticeable through senses of feeling or hearing at duct joints. Test ductwork for leaks at 1-1/2 times operating pressure but at a minimum of 2" of water.

## 8. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections:

NFPA 90A Installation of Air Conditioning and Ventilation system for Air Movement.
NFPA 90B System Component ; Fire integrity of building construction & Equipments.
SMACNA 2004 & 2005
ASHRAE 90.1
ASTM American Society of Testing & Materials

Equivalent to mentioned codes and standards may be approved by the Consultant on theprovision of evidence of equivalent by the contractor.

# AIR DEVICES

## 1. SCOPE

Supplying, fixing, furnishing, balancing and testing of Diffusers, Registers, Grilles & Louvers ofdifferent types and capacities as per drawings, specified herein and instructed by Consultant.

## 2. DESCRIPTION

i. Diffuser, grilles and registers shall be factory fabricated constructed and shall distribute the quantity of the air specified, evenly over space intended without causing noticeable drafts over an air velocity of 50 f.p.m. in occupied zone or dead spots anywhere in the conditioned area. The contractor shall be responsible for correct diffusion, spread, drop, and throw. If according to the certified data of the manufacturer of the proposed units, the sizes indicated will not perform satisfactorily, the units shall be re-selected at no extra cost to perform quietly and effectively in accordance with the manufacturer's recommendations as approved by the Consultant. A schedule of all air inlets and outlets indicating location, type specified air quantity, neck of face velocity, sound power level valves, pressure drop, throw and drop for registers, and maximum and minimum diffusion range shall be submitted for approval. The inlets and out lets shall be sound rated and certified in accordance with Equipment Test Standard 106 2R2 of Air Diffusion Council in sound power levels, decibels reference 10 - 12 watts, in octave bands 2 through 8. Diffusers and registers shall be provided with volume control and accessible operator. After the system is in operation, if excessive noise, draft, or dead spots, are noticeable in the conditioned spaces due to improper selection of type and size of diffuser or grille. The unit shall be changed to the proper size and type without additional cost.

ii. Diffusers shall be furnished with anti smudge device, unless the diffusers unit minimizes ceiling smudging through design factors. Sponge rubber gasket shall be provided between ceiling and surface mounted diffuser or anti smudge ring. Duct plenum connecting the duct to diffuser shall be air tight and shall not be interfered with volume controller.

iii. Grilles and registers shall be four-way directional- control type except that return and exhaust grilles may be fixed horizontal or vertical louver type. Each register shall be provided with removable key operated opposed-blade volume-control damper, Registers and Grilles shall be provided with sponge rubber gasket between flange and wall or cabinet, or ceiling. Four- way directional control shall be achieved by individual adjustment of horizontal and vertical vanes.

iv. All diffusers, registers and grilles to be installed in fire rated walls or ceilings shall have one-hour rated fire dampers.

iv. All diffusers, registers and grilles shall handle the air quantities shown on the drawings at rated noise levels not to exceed the Noise Criteria Curve ratings shown below:

a. Less then NC 30 for classroom, private offices, conference rooms, libraries, residences, tape rooms and audio-visual rooms.

b. Less then NC 40 for large offices, corridors, storage rooms, supply rooms, tearooms and dining rooms.

c. Less then NC 50 for workshops, repair and maintenance areas, mechanical roomsand generator rooms.

vi. All diffusers shall be insulated directly to the supply air duct & shall be so installed that the collar shall be flush with ceiling. Gasket shall be used to prevent leakage's

vii. Registers & Grills on side wall shall be fixed on wooden frames provided with anti-termite solignum treatment

viii. Plenum for linear diffuser shall be fabricated for linear diffuser using 20 gauge G.I sheet metal. Plenum shall be provided with hanging holes at every 1200 mm center, intake round spigots at 1200 mm center unless otherwise indicated on drawings, arrangement for fixing linear diffuser without visible screws & assuring leak proof fitting into the plenum

ix. The louver shall be provided with insert screen, so installed as to removable for cleaning & replacement

x. The blade & frame of exhaust & intake air louvers shall be of heavy gauge extended aluminum section provided with powder coating.

xi. Sponge neoprene, rubber, vinyl or felt border gaskets shall be provided for all surface- mounted registers, grilles or diffusers.

# PIPE WORK AND INSTALLATION

## 1. SCOPE

Supply, installation, testing and commissioning of pipes work with all and accessories for Mechanical Works complete in all respects as specified herein and as per drawings, instructionsof Consultant.

The layout of the pipe work shown on drawings are tentative and for tender purpose only. Final layout of the respective pipe work shall be prepared by the contractor in accordance with the equipment layout. The final layout as prepared by the contractor shall be submitted to the Consultant for approval and work shall be started on receiving approved drawings.

## 2. PIPE WORK INSTALLATION

The Engineer shall have the right to inspect any pipe, pipe joint, or pipe line fitting in order to check quality of materials and workmanship or system operation. Any defect should be made good by the contractor at his own expense and to the satisfaction of the Consultant.

Any pipe work fitted in any unsightly manner and not to the satisfaction of the Engineer should be removed and refitted at the contractor's own expense.

Unless specifically stated, the term "diameter" is the nominal diameter as designated commercially.

All pipes should be at least 150mm from lighting and power cables or conduit unless otherwise indicated on the drawings.

Pipes should be spaced in ducts and below floors in a manner, which will permit access to any pipe for maintenance or removal without disturbing other pipes.

Pipe should not be solidly built into wall or finishes, and joints should not be formed in any un- accessible position.

Pipes should be fixed with a minimum clearance of 25mm between the surface of the pipe or insulation and finished surface of walls and a minimum 75mm from finished surface of floor atthe lowest point and 50mm from the soffit of a ceiling.

Pipe shall be cut accurately to measurement established on the job site and worked into place without springing or forcing. All piping shall be installed with sufficient pitch to insure adequate drainage.

Each vent terminal shall be extended at least 1000mm or 3 ft. above the roof slab to minimize the possibilities of clogging and the return of foul air to the building.

Where different sizes of pipes, or pipes and fittings are to be connected, the proper size increase or reducers or reduced fittings shall be used between the two sizes.

Any fitting or connection which has an enlargement, chamber, or recess with a ledge, shoulder, or reduction of pipe area that offers-an obstruction to flow through the drain is prohibited.

## 3. PIPE SUPPORTS AND HANGERS.

All pipe work should be adequately supported on purpose made pipe supports to the satisfaction of the Consultant. Supports shall comply with B.S. 3974 whereas applicable. The supports should be selected for the particular duty, they are to perform and should be adequate for the loads and thrust imposed upon them and shall allow free longitudinal movement and expansion of the pipe work.

The anchors shall not impose forces on the structure in excess of that which the structure can withstand.

All necessary "U" bolt or other guides should be provided to counteract side or vertical movement of pipe due to expansion. All supports should be graded to the required level of air elimination and drainage. Flexible supports should be used where vibration could be transmitted through the support. Pipe supports should not be attached to any piece of plant, equipment of other pipe.

Pipe fixing and supports should be arranged at intervals not greater than the distances as indicated on drawings.

Pipe holder or supports should be of brass, prefabricated mild steel brackets or plastic chips, which should be lined at the actual point of support such that contact of dissimilar metals cannot occur.

The contractor should be responsible for the position and alignment of all built in brackets and support before concreting commences and for ensuring, that the positions are maintained until the concrete has hardened.

All vertical pipes shall be supported so as to prevent sagging and swinging.

Pipes at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment, valves and control valves. Piping shall be supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

All channels, angles, plates, clamps etc necessary for the fastening hangers shall be furnished and fitted by the Contractor. All hangers shall be properly sized for the pipe to be supported. Oversized hangers shall not be permitted, without Consultant approval.

Details of hangers and supports to be used by the Contractor shall be submitted to the Engineer for approval before fitting. All hangers shall be provided with lock nuts and have provision for vertical adjustment of pipes.

Parallel groups of pipes shall be supported by trapeze type hangers of steel construction.

Individual horizontal piping shall be supported by hangers consisting of malleable split rings withmalleable iron sockets, or steel clevis type hangers, or roller hangers as directed by the Consultant.

Vertical piping shall have heavy wrought iron or steel clamps securely bolted on the piping with the end extensions bearing on the structure of the building.

Piping shall be anchored where required to localize expansion to prevent undue strain on piping and branches. Anchors shall be entirely separate from hangers and shall be heavy forged or welded construction of approved design.

## 4. MASKING PLATES

Where pipes pass through walls, floors or ceiling, the hole should be closed with G.I. Sheet metal masking plates fitted around the pipes and over the sleeves. Where necessary, the plates should be shaped to suit the building structure. Pipe should be spaced to allow standard split plates to be fixed without cutting.

Wherever possible and where this involves special fittings or settings of pipes, even though not shown on the drawings, such fittings should be provided by the contractor at no extra cost.

## 5. PIPE SLEEVES

Sleeves should be fitted to pipes at all points where the pipes pass through walls, floors and ceilings and the contractor should be responsible for the accuracy, correct alignment and levels of all holes required to be left or cut for the fitting of sleeves.

All sleeves required to be built into or embedded in the structural concrete should be placed in position by the contractor before the concrete is placed. The contractor should ensure that the sleeves remain in the correct position while concreting takes place and until the concrete has hardened.

Sleeves for copper pipe work, should be either copper or plastic and for mild steel, either mild steel or plastic.

The weight of pipes should not be born by sleeves, and all pipes must be set concentric with their sleeves with a suitable clearance all around to allow free movement of pipes under all conditions of operation. All sleeves through walls should finished flush with the finished surface of the wall.

Sleeves passing through external wall, water proof membranes and roofs should be made water tight using a suitable flashing and water proof compound, all integrated into the building structure and to the approval of the Consultant.

## 6. PROTECTION AND PAINTING

Open ends lefts before or during the progress of the works should be protected by the use of purpose made iron or plastic caps, and plugs. Wood, paper, rage or other such materials should not be used. All pipe work should be stored in purpose made pipe racks above the ground and ends shall be protected by plugs or caps.

## 7. STEEL WORK FOR PIPE SUPPORTS

All steel work used for the fabrication of hangers, pipe supports brackets and anchors, should be hot dip galvanized as per BS 729 after fabrication before fixing. The exposed to weathersteel work should be further protected by applying one coat of zinc primer before installation following the two coats of corrosion resistant paint after installation.

## 8. PIPE WORK MOVEMENT

Wherever possible provision for movement of pipe work due to expansion and contraction should be made by changes of direction. Where this is not possible adequate expansion loops and expansion joint should be provided as necessary.

Connections to branch mains should be made in such a manner as to avoid under stress being forced upon them due to expansion and branches should be pre-stressed by cold spring during erection.

Expansion loops should be shop manufactured and annealed after welding and each leg of the loop should be pulled or compressed cold to approximately 50% of the estimated expansion or contraction on each leg.

All expansion blow should be of the axial or angular compensated type with end connections to suit the pipe work to which it is connected.

Unless otherwise specified all pipe work should be adequately guided both upstream and downstream of any expansion compensating device or anchor. All expansion devices should be installed such that no damage to the structure result from their action.

Where pipe work crosses expansion joints in the building a flexible joint shall be provided to take account of both movement of the pipe work and of the building structure. Axial compensators should not be used on suspended pipe work.

## 9. UNDERGROUND PIPE WORK

Piping in ground shall be laid on a firm bed for its entire length. No separate payment shall be made for any earthwork required in connection with laying of piping in ground.

## 10. PIPE WORK JOINTING

### a. THREADED JOINTS

The threads of all pipes shall be effectively covered with a good quality grease or other suitable compound, and each pipe be above 50 mm (approx.:2") nominal bore shall have a protecting ring affixed to the un-socketed screwed end.

Unions and flanges should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flanges being connected should be alike in all cases. Unions and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank.

### b. WELDING

Unless otherwise noted on the drawings, welding shall be done in accordance with latest edition of BS 4515.

All welders employed on pipeline fabrication must be qualified in accordance with BS 4515. Unless otherwise stated on drawings, all joints on piping 50 mm and larger shall be butt welded type.

Prior to start of welding work on pipelines, a detailed procedure specification shall be established and qualified to demonstrate that welds having suitable mechanical properties (such as strength, ductility and hardness) and soundness can be made by this procedure. This procedure shall be submitted to Consultant for approval.

Before being welded, all surfaces must be clean and free from rust, paint, oil, scale or other detrimental matter.

Pipe shall be properly supported and aligned by jigs, or clamps as required in order to preclude extraneous load and minimize strains during tackling. Small tack welds penetrating to the bottom of the groove may be used in fitting up.

Small tack welds used for fit-up, if free from cracks may be included in the first pass provided they have been made up by a qualified welder to the same procedure as that required for the first pass. Defective tack welds shall be clipped out before laying the firs pass.

After preparation and fit-up, weld joints shall be made by qualified welders as per approved procedure.

All welding shall be supervised and records maintained to ensure that each weld can be subsequently identified with the individual welder concerned.

Electrodes shall be kept clean and dry and stored in a heated place. The issue of electrodes shall be supervised to ensure the use of correct electrodes and the rotational consumption of stocks. Electrodes shall be dried according to manufacturer's recommendations.

Sections of pipe shall not be welded together for lengths below 3 meters and the numberof welds shall be kept to a minimum for longer lengths.

For all fabrication, the complete circumference of the first five welds of each welder shall be radio graphed. The radiographs shall be retained for examination and approval by the

Engineer. Minor defects in welds may be repaired provided complete records are kept and passed to the Consultant when he inspects the finished work. Major defects which might indicate incorrect choice of materials or unsuitable welding procedure shall be reported back to the Consultant in writing for a decision.

Defects in welds requiring repair shall be removed by flame or arc gouging followed by grinding and dressing.

Projections of weld metal into the pipe bore at welded butt joints shall not exceed 1.5 mm. Excessive projections on accessible joints should be removed. Welds attaching welding neck orifice flanges to pipe should be ground smooth on the inside.

Imperfections such as cracks, incomplete penetration, weld under-cutting and reinforcement shall be examined visually and made good wherever necessary.

In addition to tolerances contained within the specified codes or standards, the following also applies.

All linear dimensions involved in the relative position of branches, bosses, flanged ends, flow instrument tapings and changes in direction each to each other shall be maintained within ± 3 mm.

All angular dimensions of bends and branches shall be maintained within ± 1/4°.

Alignment of flanges and branch welding ends measured across any diameter shall not deviate more than 3.5 mm/m of diameter.

## 11. PIPE WORK MATERIAL

### a. CHILLED WATER PIPE WORK

Chilled and Heating Hot Water: Piping 2-1/2" larger Schedule 40 seamless black steel pipeper ASTM A-53B,type S standards, with welded joints using Schedule 40 seamless steel long radius fittings, ASTM A234 & ASA B16.9 & ASTM A181 OR A105 for flanges. Piping 2" and smaller Schedule 40 black steel pipe, ASTM A-53B, type S standards with 150-lb., ASTM A47 malleable iron screwed fittings.

Vents and Relief Valve Discharge: Schedule 40, galvanized steel, ASTM A-53, with 150 lb. galvanized malleable iron, screwed fittings.

Unions, On All Piping 2" Diameter and Smaller: 250 lb. malleable iron, ground joint pattern, brass to iron seat, FS W-26-531 or ASTM A47, Grade 32510 Black.

Flanges On All Piping 2-1/2" Diameter and Larger: 150 lb. forged steel, for steel pipe & 150-lb. slip-on, ASTM A181 Use flat-faced flanges against equipment with flat faced flanges.

Flange Gaskets: Mineral fiber, 1/16" thick, equivalent to Garlock #900.

Bolting Materials: Carbon steel heavy hex bolts and nuts, ASTM A307, Type B.

Pree Formed Polyurethane (Aluminum Foiled) pipe insulation with 80 kg/m$^3$ density and thermal conductivity not more than 0.04 w/m.k shall be applied over the chilled water circulation pipes.

Thickness of insulation for pipes sizes upto 2‘ diameter shall be 1‘; for 2-1/2‖ to 4‘ diameter, the thickness shall be 1-1/2‖ and for 6‖ and above diameter the thickness shall be 2‖ or as specified. The pipe insulation sections shall be one piece units with a slit along are wall length which shall open for application and close tight one the sections will be placed.

The insulated pipes exposed to weather and in plant, room shall be protected with the covering of 26 SWG G.I sheet metal jacket.

## b. CONDENSATE DRAIN PIPE

Medium quality galvanized iron (G.I.) pipes conforming to BS 1387 shall be used for condensate drain from the cooling coils/evaporative unit. Near to the drain tray, an U-trap with min. 2‖ water seal shall be installed. The entire length of the drain pipe shall be covered with 10mm thick slop-on expanded foam rubber insulation having the thermal conductance of 0.03 W/m.k.

The indoor insulated drain pipe shall be covered with PVC self adhesive finishing tape with 20% overlap. The insulation exposed to the weather shall be further protected with the covering of 26 SWG Aluminum cladding.

The exit points of the insulated drain pipes from the building shall be completely water tight so that rain water should not be entered in the building.

All pipe work should be installed as per approved shop drawings.

## c. GALVANIZED IRON PIPE WORK AND FITTNGS

All screwed pipes and sockets shall have B.S. pipe thread in accordance with B.S. 21. In order to prevent damage to the leading thread, the ends of the sockets shall be chamfered internally.

A complete and uniform adherent coating of zinc will be provided for galvanized pipes

Every pipe length shall be tested at the manufacturer‘s place to a hydraulic test pressureof 700 psi and shall be maintained at the test pressure sufficiently long for proof and inspection.

Pipe which are bundled shall be secured together by rope or soft iron or other suitable material.

The threads of all pipes shall be effectively covered with a good quality grease or other suitable compound and each pipe be above 2‖ nominal bore shall have a protecting ring affixed to the un-socketed screwed end.

All pipe fittings up to 3‖ dia. shall conform to B.S 21 and shall be of malleable cast iron. Pipe fittings above 3‖ dia. shall be of approved material and specifications as decided by the Consultant.

Unions and flanges should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flanges being connected should be alike in all cases. Unions and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank.

The run and arrangement of all pipes shall be as shown on the drawings and as directed during installation. All vertical pipes shall be erected plumb and shall be parallel to wall and other pipes. All horizontal runs of piping shall be kept close to walls. If required to change the location etc. during the currency of the work, the Contractor will do so at no additional cost.

Screwed joints in G.I. pipes shall be made perfectly tight, without the use of any filler exceptapproved jointing compound or tape. Wherever required to make flanged joints, they shall conform to B.S. to Table D.

Suitable and substantial number of hanger‘s supports and clamps of approved type and make shall be provided for all horizontal and vertical piping.

Horizontal piping shall be supported in the following manner:

| PIPE SIZE | MAXIMUM SPACING OF HANGER | ROD SIZE |
|---|---|---|
| (Dia. Inch) | (Feet.) | (Inch) |
| 1/2 to 2 | 10.0 | 3/8 |
| 2 ½ to 4 | 10.0 | ½ |
| 6 | 12.0 | ½ |

Hangers shall be supported from approved concrete inserts in concrete slab. No piping shall be hung from the piping of the systems. Long radius bends shall be used wherever possible.

Underground G.I. piping shall be wrap with PVC tape with 20% overlap.

The piping shall be painted according to a color code approved by the Consultant.

All water distribution system shall be tested whole or in part to 1-1/2 times the working pressure. The Contractor shall pay for all devices, materials, supplied, labor and power required for the test. The test will be run for two hours at revealed by the test shall be repaired and the whole test return until the system proves to be satisfactory.

# VALVES AND ACCESSORIES

## 1. GENERAL

Supply, Installation of valves and other pipe work accessories as indicated on drawings, specified herein and as per instruction of Consultant.

## 2. VALVE DESCRIPTION

Unless otherwise specified, valves should be of the same nominal size as the size of the pipe line to which they are connected. All valves that incorporated packed glands should be capableof having glands packed when connected in line and subject to the working line pressure.

All isolating valves shall provide tight shutoff in the closed position.

All hand wheel valves shall rotate clockwise to close the valve. Check valve should be install ina plane only, which is recommended by the manufacturer and approved by the Consultant.

Valve bonnets and covers should be easily removable and the gasket and glands should be readily renewable.

All gate and sluice valves shall incorporate guides in the body to ensure the correct position of valve discs at all times. The working parts of valves and cock should be bronze and the body casting should be bronze for valves and cocks up to 50 mm. connection and cast iron for valves and cock of 65 mm. diameter connection and above.

Gland rings and spindles should be of a good running fit and stuffing boxes should be fitted with neoprene 'O' ring seals. The exterior finish of all bronze valves bodies should be polished except otherwise specified.

Check valves up to and including 65 mm. diameter should be of 'Y' pattern swing type having regrindable bronze discs with the disc seat integral with the valve body. The disc and seat should be accessible via a screwed cap for regrinding without removal of the disc.

Isolating valves for all water piping should be full way type gate valves unless otherwise indicated and should be fitted in the following positions, whether shown on drawings or not:

- Inlet and outlet connections to pumps.
- Inlet and outlet connections to water strainers and filters
- Inlet and outlet connections to tanks.
- Inlet and outlet connections to three Port Valves.
- By pass connection around valves and equipment.
- Branch connection from service mains.

- At top or base of the riser served from below or above.

## 3. ACCEPTABLE STANDARD FOR VALVES AND COCKS

The following valves should be those used for all systems, unless otherwise specified.

3.1 Valves: Chilled Water and Condenser Water.

a. Gate Valves, 2" and Smaller: non-rising stem, MSS SP-80, Class 150, body and bonnet ASTM B62. Cast bronze composition. Threaded ends. Solid disc, copper-silicon alloy stem, brass packing gland.

b. Gate Valves, 2-1/2" and Larger: MSS SP-70, class 125 iron body, bronze mounted, solid wedge, ASTM A126, Class B cast iron, flanged ends with Teflon impregnated packing and 2 piece packing glass.

c. Butterfly Valves: 150 psi tight shut-off, ASTMA126:

1) Body: Wafer type, iron.
2) Disc: Cadmium-plated ductile, iron for chilled water (bronze, or aluminum bronze for Condenser Water)
3) Stem: Solid one-piece, 304 or 316 or 410 stainless steel.
4) Seat and "O" Rings: EPDM O-RING
5) Upper and Lower Stem Bearings: Bronze or reinforced Teflon.
6) Operators: Valves 6" and smaller, Victaulic #700 with lever handle. Valves 8" and larger,Victaulic No. 701 manual gear operator and disc position indicator.

d. Globe Valves 2" and Smaller: MSS SP80, shall be of Class 150, body and bonnet of ASTMB62 cast bronze composition, threaded or solder ends, copper silicon alloy stem, brass packing gland, Teflon-impregnated packing, and malleable handwheel.

e. Globe valves 2-1/2" and Larger: MSS SP85 shall be Class 150 iron body, bronze mounted with body and bonnet conforming to ASTM A126, Class B cast iron, flanged ends, with Teflon-impregnated packing and 2 piece packing gland assembly.

f. Plug Valves, 2" and Smaller: lubricated plug type, 200 lb., water operating gage pressure iron body and plug, regular pattern, threaded, with indicating arc; Equal by Walworth, Homestead, or WKM.

g. Plug Valve, 2-1/2" and Larger: lubricated plug type, 200 lb. water operating gage. Iron bodyand plug, regular pattern, flanged, with indicating arc. Equal by Walworth, Homestead, or WKM.

h. Check Valves 2" and Smaller: MSS SP80, shall be of Class 150, threaded ends, body andcaps shall be of ASTM B62 cast bronze composition, swing type disc.

i. Check Valves, 2-1/2" and Larger: Mss SP71 shall be iron body, class 250 bronze mounted with body and cap conforming to ASTM A126, Class B, cast iron, flanged ends, swing type disc.

j. Non-Slam-Check Valves (Pump Discharge): with semi-steel body, bronze trim, top and bottom center guide, stainless steel spring and 150lb. flanged ends.

k. Air Vents: manual type, of size for proper venting. Install at high points of systems.

3.2 Valves: Hot Water Heating, Low Pressure Steam & Condensate Return System.

a. Gate Valves, 2" and Smaller: MSS SP80, shall be of Class 150 with body and union bonnet ofASTM B62 cast bronze composition, threaded ends, solid disc, copper-silicon stem, brass packing gland, Teflon-impregnated packing, and malleable hand wheel.

b. Ball Valves, 2" and Smaller: Shall be PN-16, Class 150 have cast brass/bronz bodies, replaceable reinforced Teflon seats, conventional port, blowout proof stems, chrome plated brass ball, and threaded ends with extended solder cups.

c. Gate Valves, 2-1/2" and Larger: MSS SP70, shall be Class 150 iron body, bronze mounted, with body and bonnet conforming to ASTM A126, Class B, cast iron, flanged ends, with Teflon-impregnated packing and 2-piece packing gland assembly.

d. Globe Valves, 2" and Smaller: MSS SP80, shall be of Class 150 with body and union bonnet ofASTM B62 bronze, copper-silicon alloy stem, brass packing gland, Teflon-impregnatedpacking and malleable hand wheel, threaded ends.

e. Globe Valves, 2-1/2" and Larger: MSS SP85 shall be Class 125 body, bronze mounted, with body and bonnet conforming to ASTM A126, Class B, cast iron, flanged ends, with Teflon- impregnated packing and two-piece packing gland assembly.

f. Check Valves, 2" and Smaller: MSS SP80 shall be Class 150 with body and cap of ASTM B62 bronze composition and threaded ends. Class 150 valves shall have lift-type Buna-N disc andunion caps, and are to be used in lines with globe valves.

g. Check Valves, 2-1/2" and Larger: MSS SP71 shall be iron body, class 250, bronze mounted,with body and cap conforming to ASTM A126, Class B, cast iron, flanged ends, and swing- type disc.

h. Valves on steam mains in boiler rooms shall be angle globe valves and be set to hold no condensate.

3.3 **Valves: General**

a. All handles or hand wheels on all valves shall be removable and, unless specified to be of loose key type, shall be securely fastened to their stems. All valve hand wheels except thoseon radiator valves, shall be of steel, brass, or cast iron.

b. All boiler shut-off valves and valves on steam mains installed more than 6'-0" above floor, shall be furnished with chain wheels and chains to within 6'-0" of floor. All chains shall be free hanging and in a position to permit operation of valve from floor. When pulleys or extensions are required to locate these chains in such a position, Contractor shall furnish and install said pulleys or extensions as required to make a satisfactory operating installation. Extensions over 1'-0" long shall be fitted with a supported outboard bearing.

c. Furnish and install chains or wire rope with required accessories to open safety valves from boiler room floor.

d. Ball float valve should be the internally hydraulically balanced double seated pattern. The operating mechanism should be properly fixed to an arm of brass which in turn shall be fixed to tinned copper float. The valve body shall be of bronze body. The valve faces shall be synthetic rubber. The hinge pin and bushes shall be copper alloy.

e. Regulating valves for all water services for size 50 mm and smaller should be lock shield pattern disc type with parabolic shaped slotted disc and shall regulate the flow in proportion to the lift of disc.

f. Regulating valves larger than 50 mm size shall be globe patter valves.

## 4. STRAINERS

Strainer should be 'Y' pattern and cast iron body, working pressure should be equal to or greater than the maximum water pressure. The drain cock should be provided for cleaning purpose.

## 5. CAP

Should be machined, gasketed, and with straight threads or bolted type.

# WATER TREATMENT SYSTEM FOR CHILLED WATER CIRCUIT

## 1. CHILLED WATER SYSTEM

Water treatment for this system shall be by means of adding chemicals into the system by using Bypass feeders. Shall be of 5 gallons capacity and shall be constructed from minimum 3mm thick steel sheet, with cast iron cap tapped for 25mm feed line and valves sight glass, all suitable for minimum 125psi working pressure. Bypass feeder shall be provided with corrosion resistant epoxy lining on inside, two layers of lead oxide primer on outer surface & final coat of stove enameled paint.

## 2. CHEMICALS

### a. General

Water treatment chemicals, sufficient for one year operation of the system at 70% average load, shall be supplied. For Industrial building, this shall be based on 10 hrs. per day & 5 days per week. The quantities of chemicals shall be based on actual analysis of water available for make-up and for this purpose, the contractor shall be responsible for obtaining and analyzing sample of make-up water and must submit water analysis report along with detailed calculations for the verification of quantities of chemicals offered.

The following chemicals or approved equivalents shall be supplied for the systems.

### b. Chilled Water System

Corrosion inhibitor for Chilled water closed system.

# WATER TREATMENT SYSTEM FOR CONDENSER WATER CIRCUIT

## 1. CONDENSER WATER SYSTEM

### a. Flowmeter-Pulser

A Flowmeter-Pulser shall continuously monitor the make-up water quantity to the cooling towers and shall feed inhibitor chemical to the make-up water line in direct proportion to the make-up water quantity, through a chemical metering pump.

The Flowmeter-Pulse shall be magnetic drive turbine type meter with bronze body, straight reading register, center sweep hand protected by high impact glass, permanently hermetically sealed between a glass dome and metal housing. The flow meter shall have minimum 7- digit totalizer and shall be suitable for 0-55C service temperature and 10 bar maximum operating pressure. Flow meter shall comply with or exceed all AWWA Class-1 turbine meter performance standards.

Flowmeter-Pulser shall be similar to type RFP.

### b. Conductivity Controller

A conductivity controller shall continuously monitor the system water conductivity. When the conductivity of the re-circulating water reaches the pre-set maximum value, the controller shall automatically activate solenoid bleed-off.

The controller shall be menu-driven microprocessor based, with following features:

i. Vacuum fluorescent alphanumeric digital display with 0-6000 micro Siemens controlrange.
ii. LED type indicators for bleed, biocide-1 and biocide-2 outputs to indicate pump controlstatus.
iii. Isolated 4-20 mA recorder output signal for computer interface.
iv. Lithium battery to provide non-volatile set point memory backup and to provide a 24-hourbased real time clock.
v. Two independent, alternating, programmable biocide feed functions, operating on afourteen-day cycle with adjustable pre-set function and programmable lockout timer.
vi. Flow switch with back flow check valve.
vii. Temperature compensated, flat surface carbon electrode of PVC construction.
The controller shall be housed in a NEMA 4X fiberglass enclosure with hinged, lockablecover with gasketed, polycarbonate full view window.

### c. Inhibitor feed Pump

Inhibitor feed pump shall be an instrument responsive electromagnetic positive displacement chemical metering pump, suitable to accept signals from the flowmeter- Pulser and to automatically feed inhibitor chemical in proportion to the make-up water quantity. Pump shall be housed in totally enclosed, corrosion proof glass fiber reinforced polypropylene housing. Pump output shall be adjustable by readily accessible dial knob for stroke length. Pump capacity and injection pressure ratings shall be appropriate for the application. Pump shall be complete with suction and injection fittings, polyethylene tubing and a pressure relief / anti-syphon valve.

### d. Biocide feed Pumps

Biocide feed pumps shall be electromagnetic positive displacement diaphragm type chemical metering pumps. Pumps shall be housed in totally enclosed, corrosion proof glass fiber reinforced polypropylene housing. Pump output shall be adjustable by readily accessible dial knob for stroke length. Pump capacity and injection pressure ratings shall be appropriate for the application. Pump

shall be complete with suction and injection fittings, polyethylene tubing and a pressure relief / anti-syphon valve.

e. Bleed-off Valve

Solenoid operated cooling tower bleed-off valve shall be normally closed, 2-way, diaphragm, internally piloted valves with brass body and epoxy encapsulated UL listed coil and shall be suitable for outdoor use.

## 2. CHEMICALS

### a. General

Water treatment chemicals, sufficient for one year's operation of the system at 70% average load, shall be supplied. For industrial application shall be based on 10 hrs per day,5 days per week. For hospitals, hotels & similar continuous setup any project this shall be based on 24 hrs per day, 7 days per week. The quantities of chemicals shall be based on actual analysis of water available for make-up and for this purpose, the contractor shall be responsible for obtaining and analyzing sample of make-up water and must submit water analysis report along with detailed calculations for the verification of chemicals offered.

The following chemicals or approved equivalents, shall be supplied for the systems.

### b. Condenser Water System

Non-chromate based scale / corrosion inhibitor to prevent scale an to inhibit corrosion Non-

oxidizing algaecide, similar to control microbiological growth.

Non-oxidizing fungicide, similar to control microbiological growth.

Algaecide and fungicide shall have different chemical structures to prevent development ofimmunity by algae, slime etc.

Oxidizing biocides will not be acceptable.

## 3. WATER ANALYSIS

The Contractor shall be responsible for obtaining a water sample of the water to be used for make-up and having it chemically analyzed to calculate the rate of addition of various chemicals.

## 4. WATER TREATMENT PROGRAM

This contractor shall be responsible for providing a complete water treatment program for the water circuits. The program shall indicate the testing procedures, the rate of addition of chemicals, the concentration of chemicals to be maintained in the system and type and frequency of service. All this information shall be submitted in an approved format bound in hard cover. 3 (Three) copies shall be submitted. Suitable test kits for testing water by operating personnel shall be supplied, with sufficient refills for two years of normal operation.

## 5. INSTALLATION

The water treatment equipment shall be installed by the Contractor, complete in all respects. All necessary equipment and material required for a complete installation shall be supplied and installed by this Contractor within the cost quoted. It is the intent of these specifications to obtain a completely operational system and the contractor shall be responsible for providing the same.

## 6. COMMISSIONING AND TESTING

The water treatment system shall be commissioned and tested by the contractor to the satisfaction of the Consultants. Test reports shall be submitted by the Contractor and approval obtained. During the maintenance period, the Contractor shall be responsible to make monthly service calls, conduct water analysis and submit a report on the findings to the Client / Consultants.

## 7. SPARES

Provide spares in accordance with requirement given by Consultant.

# AUTOMATIC CONTROLS FOR HVAC SYSTEM

## 1. SCOPE OF WORK

a. The Automatic Control for HVAC System, (Digital Type) As per instruction of manufacturer or authorized sole agent the contractor shall furnish and install an automatic control system, incorporating sensors, controllers and subsystem as herein specified complete temperature humidity & pressurization system. The installation of the control system shall be performed after approved shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.

b. All materials and equipment used shall be standard components, regularly manufactured for this and / or other systems and not custom designed specially for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years.

c. All wiring shall be done in accordance with all local and national codes.

## 2. RELATED WORKS

Supply, Installation, Testing & Commissioning of complete in all respects including controls sensors, DDC controller, Control wiring, flexible G.I. (plastic coated) pipe, termination, Low voltage power supply, control transformer, magnetic contractors with start/off AUTO/Manual switches etc as per specifications, drawings & as per instruction of Consultant.

## 3. QUALITY ASSURANCE

a. The control system shall be designed and installed, commissioning and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

b. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control system and shall be manufacturer‘s latest standard design that complies with the specification requirements

The manufacturer of the control System shall provide documentation supporting compliance with ISO 9002 (Model for Quality Assurance in Production, Installation and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a quality system and Framework that will assure consistency in the products delivered for this project.

## 4. SUBMITTALS

A. Submit 3 complete sets of documentation in the following phased delivery schedule:

1. Valve and damper schedules
2. Equipment data cut sheets

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3. System schematics, including:
4. Sequence of operations
5. Point names
6. Point addresses
7. Interface wiring diagrams
8. Panel layouts

B. Auto-CAD compatible as-built drawings

C. Upon project completion, submit operation and maintenance manuals, consisting ofthe following:

1. Index sheet, listing contents in alphabetical order.
2. Manufacturer's equipment parts list of all functional.
3. Components of the system, Auto-CAD disk of system schematics, includingwiring diagrams
4. Description of sequence of operations.
5. As-Built interconnection wiring diagrams
6. Operator's manual
7. Trunk cable schematic showing remote electronic panel locations and all trunk data.
8. List of connected data points, including panels to which they are connected and inputdevice (ionization detector, sensors, etc.)
9. Conduit routing diagrams

## 5. WARRANTY

a. Provide all services, materials and equipment necessary for the successful operationof the entire control system for a period of one year after beneficial use.

The adjustment required testing and repair of the system include all sensors andcontrol devices.

## 6. FIELD DEVICES

All devices and equipment shall be approved for installation in the city of Gujranwala.

A. Direct Digital Controller.

B. Temperature Sensors with accuracy of ± 2 deg F @ 73 deg F)

C. Humidity Sensors with accuracy of ± 5% RH @ range of 20% to 95%

D. Dampers motors sized for specific application

E. Automatic Control Valves, Actuator sized for specific application

F. Differential Pressure Switch

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## 7. DDC CONTROLLER

1. DDC Controllers shall be a 64 bit stand-alone, multi-tasking, multi-user, real time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of two (3) Floor Level LAN Device Network.

a. Each DDC Controller shall have sufficient memory to support its own operating system and data bases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages of each level alarmfor each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom Processes
7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

b. Each DDC Controller shall support firmware upgrades without the need to replace hardware.

c. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

d. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers for terminals.

e. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control typepoints and gradual switches for analog control type points.

2. Switches shall be mounted either within the DDC Controllers key-accessed enclosure or externally mounted with each switch keyed to prevent unauthorized overrides.

3. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

(Note: Provide I/O schedule for points needing manual override)

4. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible withoutopening the panel door.

5. Each DDC Controller shall continuously perform self- diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

6. Isolation shall be provided at all peer-to-pee network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

7. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of data BMSe or operating system software. Non- volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real time clock and all volatile memory for a minimum of 72 hours.

8. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without Manual intervention.

9. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

10. Provide a separate DDC Controller for each Supply Air Fan or equipment. It is intended that each unique system be provided with its own point resident DDC Controller.

## 8. DDC CONTROLLER RESIDENT SOFTWARE FEATURES

### a. General

1. The software programs specified in this section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.

### b. Control Software Description:

The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

a. Two-position control
b. Proportional control
c. Proportional plus integral control
d. Proportional, integral, plus derivative control
e. Automatic tuning of control loops

c. DDC Controllers shall have the ability to perform any or all the following energy management routines:

1. Time-of-day scheduling
2. Calendar Based scheduling
3. Holiday scheduling
4. Temporary schedule overrides
5. Start-Stop Time Optimization
6. Automatic Daylight Savings Time Switch cover
7. Night setback control
8. Enthalpy switchover (economizer)
9. Peak demand limiting
10. Temperature compensated duty cycling

d. DDC Controllers shall be able to execute custom, job specific processes defined by the user, to automatically perform calculations and special control routines.

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1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controller on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network. Data Based shall support 30 character, English language point names, structured for searching and logs.

2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

3. DDC Controller shall provide a HELP function key.

4. DDC Controller shall be capable of comment lines for sequence of operation explanation.

e. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controller ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm message to more fully describe the alarm condition or direct operator response.

5. In dial-up applications, operator selected alarms shall initiate a call to a remote operatedevice.

f. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.

1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored n each DDC Controllers point groups. Two methods of collection shall be allowed; either by a pre- defined time interval or upon a pre-defined change of value. Sample intervals of I minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM based buffer for trend data and shall be capable of storing a minimum of data samples. All trend data shall be available for use in 3rd party personal computer applications 9i.e Microsoft Excel, Lotus 123).

2. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator initiated automatic and manual loop tuning algorithms shall be provided for operator selected PID control loops as identified in the point I/O summary.

g. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall

be limited to authorized personnel through password protection.

h. DDC Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

i. The peer to peer network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate-processing device. The peer to pee network shall also allow any DDC Controller to access, edit modify, add, delete, backup and restore all system point data base and all programs.

j. The peer to peer network shall allow the DDC Controllers to assign a minimum of 50 password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

## 9. START-UP AND COMMISSIONING

a. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-lien. All testing calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

b. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

## 10. INSTALLATION STANDARDS

### GENERAL

1 The intention of this clause is to guide the Contractor as to the quality of installation that the project requires.

2 The installation shall conform both to manufacture's recommended procedures and allapplicable codes and regulations to the approval of authorities having jurisdiction.

3 All installations to be performed by skilled and certified technicians and trades people.

4 All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor.

5 Equipment shall be installed so as to allow for easy maintenance access. Equipment shall be installed such that it dose not interfere in any way with access to adjacent equipment and personnel traffic in the surrounding space.

6 Equipment shall be installed in locations providing adequate ambient conditions for its specified functioning, allowing for adequate ventilation and with no condensate traps.

7 Equipment with the construction team as a whole, to keep the job reasonably clear of waste material and rubbish at all times during progress of the work.

8 Under the overall direction of the General contractor, co-ordinate activities and co- operate at all times with the other contractors on the project concerning scheduling and installation of the work, all phases of commissioning and access to work areas.

## 11. CALIBRATION

1. Set control points immediately after installing controls.
2. Set up and calibrate sensors and control loops during initial start-up of the systems and check, re-calibrate and readjust as necessary during the Commissioning.
3. Submit documentation to the Owner's representative before the systems performance verification indicating the final set points of all controls and confirmation that all control systems have been checked. Documentation may be graphic or tabular.

## 12. ELECTRICAL WORK BY THE CONTROLS CONTRACTOR

1. The following clauses generally indicate the extent of responsibility for electrical wiring included for the controls system.
2. All wiring required for devices supplied under this section of the specification, regardless of the voltage, shall be the responsibility of the Controls Sub Contractor
3. All such work shall be performed in complete accordance with the Electrical Specifications and local codes and may include the following:

a. Provision of control panels, pilot lights, selectors, relays, etc. required for the proper operation of the HVAC System.

b. Conduit and wiring from the starter control circuits to the mechanical system controlpanels including 110V wiring.

c. Conduit and wiring required for the interlocking of mechanical system motor starters as required for the proper operation of the control system.

d. Wiring from pilot devices relays, contractors, or other control interface devices arerequired to complete the control system.

e. Control wiring and interlocking required for refrigeration machines.

f. Wiring from spare 15 amp. Circuit breakers in power panels for line voltage powersources where required by control system. Circuit breakers shall be locking type.

g. Wiring of mechanical component controls.

h. Power wiring and control wiring to stand alone panels and terminal unit controllers.

## 13. ELECTRICAL WORK BY THE MECHANICAL CONTRACTOR

1. Generally the Electrical Contractor shall be responsible for the electrical connectionsfrom starters to equipment motors, and the following.

a. All disconnect switches on lock-out station at motor locations where required by localcode.

b. Remote control on Hand/Off/Auto stations where they are not part of a mechanicalcontrol system panel.

c. Power wiring to line voltage thermostats controlling force flow units and unit heaters,and wiring to float devices for sump pumps, etc.

d. Space 15 amp. Emergency circuit, one on each floor for controls.

e. Supply and installation of the properly sized overload heaters in the magnetic starters and thermal overload switches.

## 14. CONDUIT, WIRING AND CABLING

1. All work shall be installed to local code requirement.
2. Where there is no alternative to supplying equipment which is not UL or CSA certified, submit such equipment to Inspection Authorities for special inspection and obtain approval before delivery of equipment to site. Such equipment must be individually identified in the Contractor's proposal.
3. Use coded conductors throughout with different coloured conductors for each phase and white wire for neutral.
4. Low voltage and communications wiring, size and type of low voltage control signal wiring shall be suitable for the service for which it will be put to use and be the responsibility of this Contractor; minimum wire size # 18 AWG.
5. Identify each wire and cable at every termination point. Identify all conduits with ¯neat‖ colour bands at no more that 7.5 m intervals and on both sides of walls and floors.
6. 120V circuits shall be, at a minimum, of # 12 AWG RW-90 copper. For runs over 50 m in length, use # 10 AWG-RW90 copper.
7. All wiring in mechanical rooms and service rooms to be in conduit or raceway. Provide 600 mm, B-X flexible connection to input and output devices where required for servicing or to accommodate vibration.
8. All communication wiring between stand alone panels and the Operator Interface shall be installed in conduit. Wiring form SAPs to TUCs does not have to be in conduit except in mechanical and electrical rooms and where direct access is not available.
9. All 120V interlocking wiring and power supplies for panels to be installed in conduit.
10. Provide 120V power supplies to all main DDC panels, separately circuited from all other loads.
11. Low voltage wiring to input and output devices from SAPs and TUCs in not required to be installed in conduit except as noted. Use plenum rated wire in areas used as return air plenums. Provide sleeves where wires pass through walls and floors. Support wires form structure or fixed equipment in ceiling spaces at minimum 2m intervals.

## 15. CONTROL HARDWARE

1. Provide metal enclosures to meet NEMA specs for mounting motor control relays, wiring terminations and components provided which require additional protection.
2. All components shall be positioned to provide easy access for maintenance or replacement.

## 16. INSTALLAITON OF CONTROL DEVICES

1. Sensors provided under this contract shall be installed in accordance with the manufacturer's prescribed procedure.
2. Sensors shall be rigidly mounted and mountings shall be adequate for the environment within which the sensor operates.

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3. Supply thermal wells of the appropriate size and type for sensing water temperatures to the mechanical contractor for installation.

4. All wires attached to sensors shall be air sealed in their steel conduits or in the wall tostop air transmitted from other areas affecting sensor readings.

5. Install labels on the inside covers of all room sensors identifying the point name usingpeel and stick labels such as the Brother™ labeling system.

## 17. INSTALLATION OF ACTUATORS

1. Where damper motors operate outdoor relief, exhaust and fresh air dampers, pretension damper drives linkage to ensure tight closure.

2. Do not install damper motors on ductwork of less than 0.76m thick without firstreinforcing it.

3. Where a damper motor is installed on an insulated surface of a duct plenum, mount it on a stand-off bracket so as not to interfere with the continuity of the insulation.

4. Locate damper motors so that they are easily accessible for testing and servicing.

5. Damper motors shall be selected for the torque requirements of the damper. Damper operators that are undersized for the application shall be replaced with larger operators, at no extra cost.

6. Provide one damper motor and linkage for every 2 $m^2$ damper section are or as required to meet the torque requirements of the damper under design air-flow conditions (or minimum of one damper motor per damper section). Do not use two motors linked together on one shaft, or by jackshaft.

## 18. PERFORMANCE TEST ROCEDURES

### OVERVIEW

The successful completion of a SEVEN (7) days acceptance test is a prerequisite to granting performance test. Before the SEVEN (7) days acceptance test may begin, the Air Washer System must be completely operational including the following;

1. Every point shall be checked end to end to ensure accuracy and integrity of systems and be signed off by the Contractor and the Owner.

2. Generic start up Code shall be written in Operation Control Language (OCL) and successfully control the systems.

3. Time schedules shall be built and in control of time controlled equipment.

4. Graphic displays must be installed and fully operational for each graphic screen pageas per the Air Washer Project Summary.

5. Each control loop measured variable, controlled variable and set point if calculated;shall be placed on a FIFTEEN (15) minute continuous trend for at least TWNTY-FOUR (24) hours to prove stability of loop.

6. Each space sensor shall be placed on a THREE (3) hour trend for One Hundred (100)samples.

7. Runtime totalizer shall be set on all digital outputs.

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8. Load/save of panel programs must be demonstrated.

9. All features of system shall have been exercised.

10. Operator shall have been briefed on operation of system.

11. A trend on one panel shall be set up for a point form every other panel. These points shall also be trended in their own panels for the same intervals. Comparison of the two groups of trends will indicate if any communication problems are occurring during the SEVEN (7) days.

12. All alarms shall be operational.

13. Calibration of all sensors.

## 19. DURING SEVEN (7) DAYS TEST

1. Power failure for building shall be simulated and system recovery monitored.

2. System must be available for Owner's representative to exercise most features of thesystem.

3. Demonstration of hardware low limits and damper interlocks will be required.

4. Spot checks of points end-to-end integrity will be carried out. If several problems are identified, a complete reconfirmation of system integrity shall be carried out by the Contractor. When reconfirmation has been completed, the 7 day test will be restarted.

5. Any upset of system operational functionality greater than 2 hours during the 7 day test shall cause the test to be restarted.

6. Printer shall be left on for complete SEVEN (7) day test. All printouts will be kept for review at completion of test. An alarm printer shall be supplied by the Contractor if none is supplied in this contract.

7. Results of all tests shall be documented by the Contractor and submitted to the Engineer for review.

## 20. TRAINING AND DEMONSTRATINS

The complete training program shall be carried out. It may be convenient to schedule this during the 7 days test period.

## 21. DOCUMENTATION

The following documentation must also be in place before completion of SEVEN (7) days testand the granting of Substantial Performance:

1. Panel layout sheets complete with point name, point address and wire identificationnumber. One copy attached to each respective panel door.

2. All points tagged with point name, point address and panel number.

3. System generated data sheets and graphics signed off by both the contractor and theconsultant showing successful commissioning of each point.

4. As-Built control drawings showing interface with existing controls.

5. As-Built ladder wiring diagrams showing all hardware interlocks and panel input or output number.

6. Complete Operators Manual.

7. Apparatus and maintenance Manual for all sensors, transducers, valves, operators,solid state relays, DDC main panels and zone controllers.

8. Graphic plates of floor plans showing sensors, terminals, devices, zoning and stand alone panel locations.

9. Electrical approval certificate.

10. All of the above information shall be bound and presented in TWO (2) manuals to be left on site.

11. A copy of each graphical screen page shall be signed off and dated by the successful Contractor and the Owner‘s representative. Any changes shall be noted. This signed set shall be left on site as the ―as installed drawings‖

In addition, a summary prints out generated by the supplied system of each group of point types for each panel shall be printed after commissioning and calibration. Each sheet shall be signed by the Contractor‘s commissioning person and the Owner‘s representatives. The print out will be stored in a binder on site for reference by all parties. If any changes are noted during spot checks the shall be manually written on the original print out with the date and signature of person noting changes.

## 22. PROJECT ACCEPTANCE

Once the above basic requirements are met and all other features of the system are complete and acceptable, Substantial Performance shall be granted. A deficiency list shall be prepared and holdbacks applied. All deficiencies shall be corrected prior to Total Performance. Warranty shall start from the date of Substantial Performance of the work.

# ELECTRICAL WORKS FOR HVAC SYSTEM

## 1. SCOPE OF WORK

The contractor shall be responsible for Supply, Laying, Installation, Testing and commissioning of complete Electrical power, controls and all type of communications System, for all the equipment and system as shown on drawings, specified herein and to the satisfaction of the Consultant. The following systems are included in allied Electrical Works.

## 2. MARKINGS

The contractor shall provide "Danger Board" and "Shock Charts" Rubber mats or any other item wherever required to comply with the requirements of local Electricity Rules and according to normal practice at no cost to Owner.

## 3. ASSOCIATED CIVIL WORKS

The cost of all civil works associated with any item of electrical works shall be included in the price quoted against respective items of Bill of Quantities for the electrical works. No separate payment for such works will be made.

## 4. INSTALLATION INSTRUCTIONS GENERAL

The Contractor shall furnish all labor and materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not such equipment is furnished by him or others.

For all equipment to be installed by the Contractor, the Contractor shall supply and install all installation materials such as foundation bolts, leveling steel, shims, clamps, cable sockets, lugs, solder, wall plugs, steel rawl bolts, washers, nuts, etc. as required and without any additional costs. In general, the manufacturer's instructions for installation shall be followed.

For any major revision from the working drawings that are deemed necessary by the Contractor due to site conditions, he shall submit the details and obtain the Consultants approval at least two weeks time before starting the such works

## 5. FIELD TESTING

Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Consultant for the purpose of demonstrating equipment or system compliance with Specifications.

All tests shall be made with proper regard for the protection of the equipment and the Contractor shall be responsible for adequate protection to all personnel during such tests.

The Contractor shall record values of the tests made on all equipment. Three copies of all test data shall be given to the Consultant for record purpose.

The witnessing of any tests by the Consultant does not relieve the Contractor of his guarantees for materials/ equipment or any defects.

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## 6. INSULATION RESISTANCE TESTS

Insulation resistance tests shall be made on all electrical equipment by using a megger tester of 500V for circuits upto 250 Volts and 1000V for circuits upto 500 volts.

The insulation resistance values of cables, transformers and switchgear etc., shall be as per B.S.S. and Pakistan Electricity Rules.

Before making connections at the ends of each cable run, the insulation resistance measurement test of each cable shall be made. If insulation resistance test readings are found to be less than the specified minimum, the cable shall be replaced and the new cable installed and tested.

All switchgears shall be given an insulation resistance measurement test after installation, before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters if equipment is found to contain moisture. After all tests have been made, the equipment shall be reconnected as required.

## 7. EARTH RESISTANCE TEST

The Contractor shall make Earth resistance tests on the earthling system, separating and reconnecting each earth connection as required.

The electrical resistance of the E.C.C. together with the resistance of the earthling leadsmeasured from the connection with earth electrode to any other position in the completeinstallation shall not exceed 0.1 OHM.

Earth resistance test shall be performed as per electrical inspector's requirements. Where more than one earth electrode is installed, the earth resistance test of each electrodes shall be measured by means of resistance bridge instrument.

## 8. CONTIUNITY TEST

Continuity test on all the sub and main circuits should be performed for phase, neutral & earth wires.

## 9. WIRE AND CABLES

The Contractor shall furnish and install all wires and cables alongwith the accessories as specified herein, in Bill of Quantities and Drawings. Apart from the material specified, the Contractor shall provide the necessary material for termination or fixing of wires and cables such as lugs, solder supports, bushes, and glands for a complete wiring installation. Miscellaneous materials, like filing compound, identification tags, markers and earthling strips shall be furnished for completion of works in accordance with the best engineering standards and practice. The wiring installation shall be carried out in strict accordance with the scheme, cable sizes and circuit details shown on the drawings or as specified. The contractor is to produce purchase certificate from recommended manufacturers like Pakistan Cables, Pioner Cables or AGE Cables for each & every lot and each and every coil of wires to be stamped by consultants before it is being sent to site for use.

## a. CONSTRUCTION

The cable for underground exposed on surface and concealed conduit-wiring system to light or power circuit shall be single/multicore, PVC insulated having soft annealed standard copper conductors. The voltage grade shall be 450/1000 volts for lights and sockets circuit and 660/1100 volt for power circuits as specified. All cables shall be tested to BS 2004-1961. Flexible cord for connection of light shall be 3 core PVC insulated PVC sheathed. The make of cables shall be as approved by the Consultant.

In general cables for wiring system shall be as under or otherwise specified or shown as drawings: -

| | | |
|---|---|---|
| Conduit Wiring | : | Single core PVC insulated. |
| Surface Wiring | : | Multicore PVC/PVC sheathed OR as specified on the drawings |

For light and power circuits the minimum size of conductor shall be 1.5 and .0sq.mm respectively and minimum size for flexible cords shall be 0.75 and 1 sq. mm for circuits protected with 10 and 15/20 AMPS. mcbs. The color code for power cables shall be red, yellow, blue for phases and black for neutral conductor, whereas for light and socket wiring, red for phase and black for neutral conductors. Specified size of earth wire, greenin color, shall be run with each circuit.

## b. INSTALLATION

The wiring through exposed or concealed conduit shall be started only after the conduit system is completely installed and all junction boxes, outlet boxes, switchboards etc. have been fixed in proper position. For outdoor installation, where specified the cables shall be run direct in ground or in pipes as specified. The cables shall be pulled through conduit or pipes with care to prevent any damage to cables. To facilitate pulling, lubrication only as recommended by cable manufacturer may be used for decreasing friction. Under no circumstances shall oil or soap be used for cable pulling. Where several wires are to occupy the conduit or pipes they shall be pulled along together with earth continuity conductor. In general, the wires shall not be bend to radius less than ten times the overall diameter of the wire, or as otherwise recommended by cable manufacturer. The contractor furnishes all installation material and labor for installation, testing and commissioning of cable system.

The wiring to power circuit and 15 amperes single phase socket outlet shall be run in conduit separate from light wiring conduits. Care shall be taken to ensure that all phase conductors are connected to the proper terminals and correct phase sequence is maintained. Wherever the size of conduit is not stated on drawings, it shall be in accordance with the following Table based on I.E.E. Regulations.

### TABLE FOR NO.OF WIRES TO BE LAID IN GIVEN SIZE OF GI CONDUIT

| WIRE SIZE (Sq.mm) | Size of conduit (mm. Dia) | | | | |
|---|---|---|---|---|---|
| | *20* | *25* | *32* | *38* | *50* |
| 1.5 | *6* | *13* | *20* | - | - |
| 2.5 | *4* | *9* | *13* | - | - |
| 4.0 | *3* | *6* | *11* | - | - |
| 6.0 | *2* | *4* | *8* | - | - |
| 10.*0* | - | *3* | *4* | *8* | - |
| 16.0 | - | - | *2* | *5* | *8* |

The wires or cables shall be terminated at points, switchboard, etc. such that the insulation is always led into the equipment to which connection is made. The cable entry hole in equipment shall be such as not to damage the cable. Inside the switchboards or control boards, the wires or cables shall be securely fanned out in a neat arrangement and laced with wax cord. The wires of different phases

shall preferably be bunched separately. Identification tags or ferrules shall be provided at termination of wires in switchboards with respect to connected equipment for ease of installation and maintenance.

## c. POWER, LIGHTING AND CONTROL CABLES

### i. Under ground Cables

PVC Cable for underground installation shall be PVC insulated, sheathed and armored with galvanized steel wire of specified sizes

### ii. Surface Cables

Cables for distribution system on surface shall be either single-core or multicore, as required and PVC insulated and PVC sheated.

### iii. Cables in Conduits

All cables / wires, in conduits shall be of copper, PVC sheathed or PVC insulated.

## d. PHASE INDENTIFICATION

All cables shall have phase identification colors on insulation of each phase. The color code for three phase circuits shall be red, yellow and blue for phase conductor and black for neutral conductor Single-phase circuits shall have red for phase and black for neutral conductor.

## e. CABLE MARKERS/TAGS

All cables either buried in ground or laid in tray have cable tags giving cables identification and from where it is coming and where it is join. These tags should be engraved on brass or starters steel sheets. Tags should be attached to cable at every two meters distance and wherever cable enters or leaves a wall/room. Cable markers should be above ground giving full detail of cables buried. Should be made of concrete with a brass sheet having required information.

## f. CABLE ACCESSORIES

Best quality cable accessories should be used with the approval of consultant. The cable accessories, include, cable tray, cable trunking, floor trunking, clips, saddles (all galvanized). Cable glands made of brass should be used when cable enters/leaves a panel/Distribution board. Identification tags made of engraved brass plates to be used for all cables. All the cables should be security fixed to cable tray or trunking with help of plastic tees. Cable lugs should be compression type of BICC U.K, Elpress Sweden or equivalent. Lugs should be pressed with help of compression machine approved by consultants.

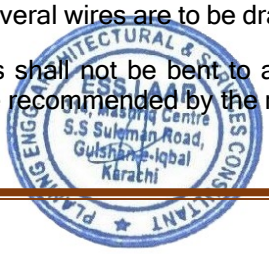
## g. CONDUIT WIRING-INSTALLATION

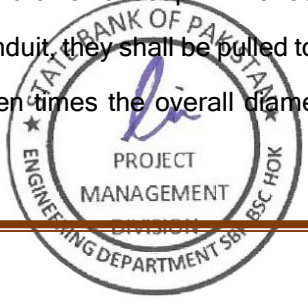
The wiring through conduit shall be started only after the conduit, system is completely installed and all outlet boxes, junction boxes, etc. are fixed in position.

The wires shall be pulled in conduit with care and, to facilitate pulling, the cable manufacturer's recommended lubricant shall be used. Use of any kind of oil or soap will not be permitted.

Where several wires are to be drawn in the same conduit, they shall be pulled together.

The wires shall not be bent to a radius less than ten times the overall diameter of the wire, unless otherwise recommended by the manufacturer.



The wiring shall be continuous between termination. The looping in system shall be followed throughout. Any joint in wires will not be allowed. The use of connectors will only be allowed at location where looping-in is rendered difficult. The consent of the Consultant in writing will be required for using connectors. The connector shall be of suitable rating having porcelain body, sunk-in screw terminals and terminal strips. The connector shall be wrapped with PVC insulation tape after its installation. A minimum of 150 mm-extra length of cable/wire shall be provided at each termination to facilitate repairs in future.

### h. SURFACE WIRING

The cables installed on surface shall be by means of steel or phenolic moulded clamps installed at a maximum distance of 500 mm.

Where specified or necessary due to site the cable shall be run in cable ducts or on cable trays.

### i. TERMINATIONS.

Terminations of all cables above 10 sq.mm shall be done employing heat shrink type termination kits as manufactured by 3M, equivalent. RACHEM or All lugs shall be compression type of high conductivity copper.

## 10. CONDUITS & PIPES

The contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, laceration and position of the electrical lines.

The conduits and pipes with accessories shall comply with the General Specifications, and with other relevant provisions of the Tender.

### a. PVC CONDUITS AND ACCESSORIES

The PVC conduits and accessories for lighting and power socket wiring wherever specified shall conform to BS-4607 (1970).

Using spring type bender or special bending machines or manufactured smooth bends shall be used where conduit changes direction, bending of conduits by heating will not be allowed in any circumstances. Use of sharp 90 bends and tees will not be allowed. The bends shall conform to the same specifications given above for conduits and should have enlarged ends to receive conduit without any reduction in the internal diameter at joint.

The round PVC junction boxes for ceiling light points shall have minimum dimensions of 64-mm diameter and 64 mm depth. The junction boxes for wall light points shall have minimum dimensions of 57-mm diameter and 40 mm depth.

### b. STEEL CONDUITS AND ACCESSORIES

All conduits supplied by the contractor for power and light wiring at specified locationsshall be of heavy gauge 14 SWG galvanized sheet steel, manufactured and tested in accordance with latest BS-31.

Each conduit length shall be furnished with threaded ends and a threaded coupling at one end.

The conduit accessories, such as sockets, elbows, bushing, bends inspection boxes, pull boxes, junction boxes, saddles, clamps, etc. as required to complete installation shall be furnished by the contractor. Metal bushes shall be used at conduit termination and entry to prevent damage to cable during pulling operation.

The junction box shall be of cast iron having 50-mm diameter and 63 mm deep. The above dimensions are given as a minimum only.

All junction boxes shall be provided with one-piece cover plate.

The conduits and conduit accessories shall be as manufactured by M/s. International Industries, Karachi, or approved equivalent.

## c. GALVANIZED IRON PIPES AND ACCESSORES

The GI pipes shall be galvanized inside and outside by hot dip-galvanizing process. The pipes shall be free from stains, burrs. The accessories for GI pipes such as socket, bend, etc, shall be galvanized inside and outside and shall be of same quality and specifications as the pipes. GI pipes for underground installations shall be given bituminous paint coatingbefore installation.

GI pipes as manufactured by M/s. IIL. or approved equivalent shall be provided.

## d. CONDUITS INSTALLATION REQUIREMENTS

### i. PVC Conduits

The conduit shall be installed concealed in wall, and installed on surface or above the false ceiling or as stated on the drawings.

For conduits concealed in cement concrete (CC) works, or in block masonry, chase shall be made with appropriate tools and shall not be made deeper than required.The conduit shall than be fixed firmly in the recess and covered with cement concrete mixture to have at least 32 mm cc cover after plaster. The electrical contractor shall be responsible for bringing back the original finish of civil works.

Conduits installed on surface shall be fixed by means of black enameled steel saddles and clamps. The clamps shall be installed at a distance of 600 mm in a manner as described for steel conduits.

At all joints PVC jointing solution must be used.

### ii. Surface Steel

Galvanized steel conduits at specified locations shall be installed Concealed or onthe surface of wall, column, ceiling, etc, by means of steel saddles and clamps of approved design.

The saddles shall be installed on surfaces by means of nylon wall plugs and galvanized steel screws. Drilling shall make appropriate sized holes in structure. Thethickness of saddles shall not be less than 3 mm and clamps shall be of 16 SWG sheet steel, or of design approved by consultant. These shall be fixed at a maximum of 1000-mm spacing along horizontal and vertical runs of conduit. All accessories for complete installation of conduit system shall be provided by the contractor.

Conduits concealed in wall shall be done as described for PVC conduits.

Under floor conduit, installation shall be at a minimum depth of 50 mm from the finished floor level when measured form the top of conduit. The conduits shall be installed empty before finishing of floor.

### iii. Other Requirements Of Conduits Systems

The termination of conduits should be shown diagrammatically on the shop drawings. The exact final location of the termination shall be coordinated with the equipment to be installed.

Conduit ends pointing upwards or downwards shall be properly plugged, in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all termination of conduit, soft bushes shall be fixed to prevent sharp edges of conduit ends form cutting or damaging the wires or cables to be pulled through them.

The entire conduit system shall be installed and tested before wiring is carried out. Any obstruction found should be cleared by use of a cutting or other approved device and the conduit by cleaned out before the installation of cable.

Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The shop drawings prepared by contractor to show pull boxes, no straight run of more than 30 feet is allowed without pull box. Each pull box should be on wall at a length of 6 feet from floor level.

The inspection boxes or pull boxes shall be of 16 (1.63 mm) heavy gauge sheet steel having nipples welded to box at entry holes to receive conduit with force-fit. The box shall be painted inside and outside with black enamel paint over a base 2 coats ofred oxide primer paint.

Wherever the conduit length crosses the expansion joint either along the column or slab, suitable arrangement shall be provided by means of flexible conduit.

**e. Cable Trays**

For surface installation of cables along the horizontal runs cable trays shall be provided. These should be made of 16 SWG' perfected galvanized M.S sheets, its sides should be strengtheners by strengthener if the width of tray is more then 30 cm.

Minimum width of tray shall be 100 mm. However, the width of tray for different number of cables shall be determined by providing 100-mm clearance between cables and 50 mm at ends. Suitable arrangement to be provided by clamps or other means at intervals to ensure that the above spacing are maintained. The cable tray shall be supported from the roof by steel hangers and to the wall by brackets. The supporting arrangement shall be secured to the civil structure using 10 mm more 12 mm rawl bolts and hanged by galvanized all thread bars of min dia 10 mm. Joints should be made with help of galvanized strips of same material of which cable tray is made of with galvanized nuts & bolts.

Drawings shall be submitted for approval before fabrication.

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# MOTOR CONTROL CENTRE

## 1. SCOPE

Supply, installation, rigging, lifting, placement of all type of motor control centers as specified as shown on drawings, specified herein and to the satisfaction of the Consultant.

## 2. GENERAL

The motor control centers shall be specified type, construction and application. All the components shall be of the sizes and type as specified, all the components provided under this contract shall be of one manufacturer except for the equipment where special motors and components are provided as standard component. The contractor shall submit manufacturers technical bulletins to the consultant for approval before supply.

The motor control centers shall be from approved manufacturers.

## 3. CONSTRUCTION OF ENCLOSURE

The construction of Enclosure shall be according to specified type and class. Max height shallbe approx. 72 inches and 12-18 inches deep. The external panel shall be of flanged 14 gauge sheet steel. Side, top, back and floor plate shall be rigidly joined by cross members and angleiron brackets.

Removable floor channels shall be provided to support and mount the entire control center. Unit compartments provide each compartment with an individual front door.

## 4. BUS

Power shall be distributed horizontally with in the control center by three phase electrolytic copper bus (99.7 % Purity), rated to the required Amperes continuous current and braced forminimum 40,000 amperes RMS asymmetrical short circuit current or as specified.

The bus shall be efficiently isolated from all wiring troughs, components and other workingareas.

Power within vertical sections shall be distributed by vertical copper bus bar. Bus bar shall be painted Red, Yellow, Blue.

All the bus bars, internal wiring, cables and other components shall be rated for 45ºCambient and bus bar end temperature of 65ºC.

Grounding copper bus shall be provided of the required amperage but not less than 200 amperecapacity in the base of the control center permanently grounding the structure.

Provide cable lugs as required for wire or cable attachment.

## 5. MOTOR STARTERS

All the starters for single phased motors shall be automatic magnet direct on line type with adjustable overload cut out, push buttons. Where interlocking is required the starter shall be additionally provided at least two auxiliary contacts for electric or electronic interlocking or asspecified.

All three phase motor starters up to 7.5HP motors shall be automatic magnetic direct on line type with adjustable over load cut outs and push buttons. Where interlocking is required the starter shall be additionally provided at least two auxiliary contacts for electric or electronic interlocking or as specified.

All three phase squirrel cage induction motor starters 10HP motors and above shall be automatic star-delta type soft start with adjustable over load cut outs and push buttons. Where interlocking is required the starter shall be additionally provided at least two auxiliary contacts for electric or electronic interlocking or as specified.

All the starter control circuit shall be separate and magnetic coils to be suitable for 220 volt, single phase.

A separate set of terminals is required for each control and power circuit.

## 6. MOTOR PROTECTION

All the magnetic starters shall have over load relays, as well as fuses unless specifically noted otherwise in the documents. The selection of over load relay shall be based on motor name plate.

## 7. AIR BREAK CONTACTORS

The Air break contactor shall be suitable rated according to the motor output rating, if not specified select rupturing capacity 25KA for up to 150 ampere and 35KA for 200-600 ampere oras specified in documents.

## 8. PILOT LAMPS & SELECTOR SWITCH

All motors installed in this contract and operated by automatic starters shall have ON-OFF-TRIP indication status on the respective panel.
In general where motors are to be automatically controlled a HAND-OFF-AUTO, selector switch shall be provided on the panel.

## 9. UNDER, OVER AND PHASE SEQUENCE RELAY

All main panels shall have under, over voltage protection and phase sequence relay.

# PAINTING, IDENTIFICATION, CHART AND TAGS

## 1. SCOPE

The contactor shall paint and identify all equipment and Mechanical works, generally piping, ductwork, insulation, metal items, equipment etc.

Polished, aluminum, stainless steel, chrome plated and other finely finished materials includinglabels, should not be painted unless otherwise indicated.

## 2. DESCRIPTION

i. Before painting metal surfaces shall be cleaned with mineral spirits to remove grease and dirt. For rust or scale wire brush or sandpaper shall be used prior to painting. For steel work, at first apply one coat of red lead primer and then two coats of rust resistant paint shall be applied. For Galvanized surfaces zinc chromate shall be used at first and then apply the final coats.

ii. Materials previously shop prime coated by the manufacturer and which have been scuffed, shall be touched up with the same materials used for priming, objectionable materials should be removed from prime coats before final painting. Prime coats should be of a lighter tint than final coat.

iii. All surface should be dry above 50 F before paint is applied.

iv. Baked enamel finishes should be of a uniform color throughout.

v. All finish color shall be as selected by the Engineer In charge.

vi. Color identification of pipelines shall be as per BS- 1710.

vii. Identification bands shall be painted on piping at frequent intervals. Lettering shall be as per BS oras agreed with the Engineer.

viii. Identification tags shall be installed on valves, controls and other parts of the system where as required. Tags shall be polished or lacquered brass or aluminum, 50 mm round or hexagonal shaped with 15mm high engraved letters. The tags shall be fastened securely with brass hook orchain.

ix. All material shall be used from approved make

## RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections:BS 1710 Identification of pipes

BS 5378 Safety color & safety sign

CP 231 Code of practice for painting

Equivalent to mentioned codes and standards may be approved by the Engineer on the provision of evidence of equivalent by the contractor.

# EQUIPMENT INSTALLATION

## 1. SCOPE

Installation of Complete Air conditioning, Ventilation systems and equipment as per drawings,specified herein, as instruction of Consultant and recommended by the manufacturer.

## 2. DESCRIPTION

i. All floor mounted equipment at grade level shall be set on 8" high concrete pads poured integrally with the floors and all floor mounted equipment above grade level shall be set on not less than 6" high structural steel beams anchored to the floor in accordance with drawings.

ii. Air handling units shall be floor mounted or suspended, as shown on the drawings, with vibration isolators furnished with the units. Isolators for floor mounted units at grade shall be fastened to the concrete pads using foundations bolts or expansion bolts and shields driven into holes drilled in the concrete. Supports for suspended units shall be shown on the shop drawings. Isolators for units mounted on structural steel members shall be bolted to the members.

iii. Air filters for air handling unit, fan coil unit and ventilating units shall be provided. Installone set in each of the units prior to testing and adjusting. At the time of handing over they shall be replaced with new ones. Install a filter gauge at each air handling unit filter bank in accordance with the manufacturer's recommendations.

iv. Support surface mounted ceiling diffusers from angles or channels resting on and fastened to ceiling T-bars or channels. (Do not support from ducts) Install lay- in diffusers for T-bar ceiling, shall be supported by ceiling structure and provide sheet metal adapter box above each diffuser to allow space for volume controller with round collars for connection to round ducts where shown on the drawings, connect duct into side of box, unless shown otherwise, on the drawings. Install volume control blades at 90-degree angle to inlet duct airflow.

v. Wall mounted and duct mounted registers and grilles shall be fastened to flanges of duct collars.

vi. All devices shall be aligned to be parallel to ceiling T-bars or walls and ceiling surfaces,and shall be pulled up tightly to compress gaskets and to fit neatly against the surfaces.

vii. Submit shop drawings for approval showing method of installing each type of equipment and device.

viii. Supply equipment shall be installed after ducts, plenums and casings have been cleaned and blown free of all small particles.

ix. The automatic equipment shall be installed in strict accordance with manufacturer's instructions, and approved by Consultant. All low-voltage (below 900 volts) control wiring or tubing shall be provided under this section of the specifications. Before the air- conditioning installation is accepted, the contractor shall deliver to Consultant a statement certifying that the automatic control equipment has been inspected and found to be properly installed and are functioning satisfactorily.

x. The control dampers in the air handling units shall be installed by the air handling unit manufacturer and in the ductwork when required, by the contractor as recommended by the automatic temperature control manufacturer or his authorized agent. All necessary blank-off plates and transitions to install the dampers in the duct system shall be the responsibility of the contractor.

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xi. Transformers shall be provided for electric or electronic controls when required. For temperature control system each transformer shall be connected to an electric circuit which serves no other equipment. Spare circuits in electric panels shall not be used for controls. Control wiring shall not be connected to lighting circuits. Power circuits are excluded except when controls serve an individual air- handling unit, in which case transformers may be connected to fan-motor leads of the unit controlled. All low voltage wiring in equipment rooms or areas where other piping is exposed shall be run within adequately supported thin- wall conduit or rigid metallic raceways.

# INSTRUMENTS

## 1. SCOPE

The Contractor shall supply and install all necessary room mounted Thermometers, Pipe Thermometers, pipe line Pressure gauges, duct mounted Thermometers, Inclined Manometers for filters, Magnahellical gauges including alarm for room pressure monitoring, for easy checking of operation of the complete plant.

All the instruments shall be provided from approved make. The contractor shall provide the calibration certificate of each instrument from manufacturer along material.

## 2 . Duct Mounted Thermometer

Insertion type duct mounted 100mm dia. dial thermometer shall be provided in each supply and return air side of each cooling and heating coil of Air handling units, and supply air of zones.

## 3 . Pipe Line Thermometer

Industrial variangle type pipe insertion thermometers at least 7 inches length. Stem length shall select on pipe dia, with external recalibration, separable copper wells and sockets with extension neck for insulated piping, shall be provided at each water inlet and outlet of water.

## 4 . Compound / Pressure gauge

Compound/pressure gauges, at least 100mm diameter with Bourdon tube type element and internal mechanism with individual bearings to give best accuracy under fluctuating pressure and vibrations shall be provided, Where only gauge cocks have been shown in The gauge cock shall be supplied with pressure gauge. Where only siphon have been shown in the drawings, only these shall be supplied.

The gauge cocks shall be of brass with lever handle and for steam gauges, a siphon filled with water shall be installed between the cock and gauge to prevent steam from entering the Bourdon tube.

## 5 . Temperature and Humidity Recorder

Two pen combination flow and temperature recorder shall be installed as shown in the drawings. One pen shall record the temperature and other shall record the humidity.

# FILTERS

## 1. SCOPE

Supply, installation, testing & commissioning of Air Filters as specified complete in all respects of various type and sizes as shown in, drawings, specified herein, & as per instruction of Consultant.

## 2. FILTER SECTION

The filter Frame/housing shall be correctly in size to fix the required no of filters and to deliver the specific volume of air.

The section shall be fabricated as specified in basic construction of air handling units.

Door shall utilize perimeter gasketing of silicon rubber. Latches shall be quick acting spring loaded and manufactured from non corrosive materials.

Each filter panel shall be independently sealed against its respective gasket surface to ensure airtight joints.

### a) PREE-FILTER SECTION

Extended surface pleated panel filters shall be 50mm thick as specified class, withsuperior dust holding capacity and 35-45 % average ASHRAE efficiency.

Tile filters shall be Pleated panel filter with low velocity handling. Filters shall be UL Listed withClass-2.

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# TESTING, ADJUSTING, BALANCING & COMMISSIONING

## 1. SCOPE

Testing, Adjusting, Balancing & Commissioning of complete Air conditioning, Ventilation and Mechanical system (Air and Hydronic side) as per specification and as per standard or instruction of Consultant from independent Testing & Balancing Agency as approved by Consultant.

All equipment shall be started by, and operated under, the supervision of the qualified and approved personal of contractor or the designated authority.

## 2. TESTING

i. All tests shall be conducted in the presence of Consultant rep, who shall be given 3 days notice before any test is to be started. Any material, equipment or instruments required for tests shall be provided by the contractor at his own cost.

ii. An approved company experienced and specialized in testing and balancing of air conditioning systems shall be hired. The company shall test and regulate all air/water handling systems and equipment and confirm that the capacities and performances of the system are as indicated on the drawings. The contractor shall furnish to the consultant in writing a statement evidencing that the testing and balancing company is already qualified in past and has experience in this type of work.

iii. All testing, adjusting and balancing shall be performed in complete accordance with SMACNA's standards, the AABC National Standards for Field Measurements and Instrumentation, Form No 12173, volume two, as published by the Associated Air Balance Council. All methods and procedures shall be adopted as mentioned for Air/Water Balancing.

iv. A qualified representative of the approved testing and balancing company shall visit the job site and take measure accordingly time to time.

v. All instruments and equipment required for balancing shall be calibrated. The Contractor shall provide the Calibration certificate prior to start testing, adjusting and balancing

vi. Furnish any special fittings or devices in the duct/pipe, systems as may be required to obtain the required data. Artificial resistance's, equal to dirty filters shall be added to the clean filter banks in air handling units by partially blanking off the filter face area. Pressure drop for test and balance shall be (0.5")

vii. Prior to any air volume testing, any furred spaces, chases, shafts etc., which are to handle air directly without the use of sheet metal ductwork, shall be checked for leakage. First seal or otherwise prevent the leakage of air through tracks or porous materials in these spaces. All voids around piping, conduit ductwork, or other services which pierce the constructions, shall be caulked airtight before making final duct connections and grille / register installation.

viii. Contractor should check the design and be responsible for correcting any mistake made inadvertently during the design stage by the designer any change should be notified to the Engineer Incharge and prior approval must be taken.

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## 3. EQUIPMENT TESTS

i. Before starting or operating any equipment systems, a thorough check shall be made to determine that all systems have been flushed and cleaned as required and that all equipment has been properly installed, lubricated and serviced. Factory instructions shall be checked to see that installations are made accordingly and that recommended lubricants have been used in all bearings, crankcases and similar equipment. Particular care shall be used in lubricating bearings to avoid damage by over lubrication and blowing out seals. Equipment shall also be checked for any damage that may have occurred during shipment, after delivery or during installation. In the event of any damage that may have occurred during the shipment, after delivery or during installation the equipment, shall be replaced, renewed or repaired to the satisfaction of Consultant.

ii. The performance of all components of equipment shall be tested under all possible variations of loads, flow conditions, temperatures, etc. which can be simulated on the jobby utilizing any of the heating or cooling equipment which is furnished as part of the work.

iii. Any equipment, systems, or work found deficient during tests shall be replaced or revised as required to the satisfaction of the Consultant. The contractor shall be responsible for the complete coordination of the piping, wiring diagrams and control diagrams with the equipment requirements.

## 4. SYSTEM TESTING AND BALANCING (TAB)

a. AIR DISTRIBUTION

All supply, return, outside air intake, and exhaust systems shall be balanced as follows.

a. Set all thermostats to the position requiring full air flow.

b. Set all manual dampers to the full open position including fire dampers and volumecontrols at diffusers and grilles.

c. Place the controls of all fans in the running position.

d. Measure the face velocities and calculate the air volume passing through the systems at the cooling coils, air filters, fan intakes, main ducts, or other approved locations

e. Adjust and readjust the manual balancing dampers, outlet volume controls and fan speeds until all supply, return and exhaust outlets are within 5% of the design air volumes. Record the final air temperature and volume at each outlet and inlet.

f. Prepare all TAB report forms and submit as required using the SMACNA TAB report forms.

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# TEST RUN

## 1. SCOPE

The contractor shall be responsible to carried out test run as specified after the issue of the Certificate of Substantial Completion for the work by the Engineer.

The period for the test run(s) would be designated by the Engineer.

All the parameters shall be recorded on printed log sheet approved by the consultant.

The contractor shall be responsible for all the tools, instruments etc required to take and record the test run observation.

The contractor shall depute an experienced staff for the test run.

The log sheet shall jointly signed by the Employer Representative. The contractor shall observe and prepare a summary of observation on printed form.

The consultant shall check the performance of the plant(s) during test run. If the plant performance meets the specified requirements, the Engineer shall issue a Certificate of satisfactory completion of test run(s) to the contractor.

## EQUIPMENT SCHEDULES

| S.NO | DESCRIPTION |
|---|---|
| 1. | WATER COOLED SCREW CHILLER |
| 2. | HOT WATER HEATER |
| 3. | COOLING TOWER |
| 4. | AIR HANDLING UNITS |
| 5. | FAN COIL UNITS |
| 6. | SPLIT TYPE AIR CONDITIONING UNITS |
| 7. | VRV AC SYSTEM |
| 8. | PUMP SETS |

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## TECHNICAL DATA SHEET FOR WATER COOLED SCREW CHILLER

| S.NO | ITEM | UNIT | DESCRIPTION FOR CHILLER |
|---|---|---|---|
| 1 | Unit Tag No | | CH-1 |
| 2 | Quantity | | 1 |
| 3 | Space Served | | Main Building S.B.P |
| 4 | Equipment Installed at | | 2nd Basement, Plant Room |
| 5 | Applicable Standard for Chiller<br>Chiller Rating<br><br>Pressure equipment regulations:<br>Efficiency | <br>:<br><br>:<br>: | <br>EN 12055 or AHRI 550/490-98, Eurovent/ Equivalent.<br>Equivalent.<br>PED / ASME / Equivalent.<br>ASHRAE 90.1 |
| 6 | Quantity | No | 1 |
| 7 | Type | | Electrical operated high efficiency water cooled Screw Compressors Chiller,Min 2 Nos Ref-Circuit 100 % to 10% modulating capacity. VFD/Invertor operated soft start and stepless control capacity regulution, high energy efficiency Screw type, Factory assembled single piece, Skid Mounted unit. |
| 8 | Ambiant Conditions | | Summer: 108.0° F db,85.4° F wb, 39.8 % RH<br>Monsoon : 95.0° F db, 85.4 ° F wb, 66.85 % RH<br>Winter : 38.0° F db, 30% RH |
| 9 | Altitude (Elevation above Sea<br>Sea Level) | Ft | 756.6 |
| 10 | Latitude | Degree | 31.166° North |
| 11 | Longitude | Degree | 74.195° East |
| 12 | Total Cooling Capacity | Tons | 300 Tons at specified conditions |
| 13 | Chilled Water Flow Rate | US-Gpm | 644.74 |
| 14 | Chilled Water Temp In/Out | °F | 54.0/44.0 |
| 15 | Cooling Water Flow Rate | US-Gpm | 910.0 |
| 16 | Cooling Water Temp In/Out | °F | 91.0/101.0 |
| 17 | Max. Sound Level<br>1.0 meter distance from unit in free field. | db | Max 80 |
| 18 | Fouling Factor<br>(Evaporator Side) | | 0.000500 (h-ft². °F/Btu) |
| 19 | Fouling Factor<br>Condenser Side | | 0.00100 (h-ft². °F/Btu) |
| 20 | Cooling Efficiency | KW/Ton | Max .680 |
| 21 | Controls | | Micoprocessor based -Controlled, for fully modulating capacity ranging 100% -10% control. Capable to interface with BMS/SCADA, with open/BACnet protocols. |
| 22 | Electrical Characteristics | Ph/V/Hz | 380 V, 3 Phase, 50 Hz. |
| 23 | Compressor & drive | | Closed-coupled Semi hermetic motor and compressor screw compressor essembly. |
| 24 | Compressor & System | | Hi-efficency,Single stage, Semi-Hermatic Screw type, Low level vibration and Noise. |
| 25 | Compressor motor | | Energy efficient min-IE2/NEMA 1 or equivalent type. |

| S.NO | ITEM | UNIT | DESCRIPTION FOR CHILLER |
|---|---|---|---|
| 26 | Type of Evaporator | | Flooded, Shell & Tube Type |
| 27 | Type of Condenser | | Water Cooled, Shell & Tube type |
| 28 | Independent Refrigerant Circuit | Nos | 2 Nos (Two individual) |
| 29 | Electrical Characteristics | V,Ph,Hz | 400 +/- 5%, 3Phase, 50 Hz |
| 30 | Coefficient of Performance (COP) | | Not less than 5.6 at full load conditions |
| 31 | Design working pressure | (psig) | 150 |
| 32 | Refrigerant | | R134a |
| 33 | Pressure Drop | Ft | 15 |
| 34 | Operating hours/year | Hr | 8,064 |
| 35 | Electrical motors protection class | | Least IP44/NEMA 1 or equivalent. |
| 36 | Inspection and Testing | | Performance shall be rated in accordance with AHRI/Eurovent standard, witness for factory test report. reports.<br>Entire chiller assembly shall be tested as per EN 378 or ANSI/ASHRAE-15. |

**Note;**

| | |
|---|---|
| 1 | The chiller package shall be factory tested as per standard and all test certificate shall be provided before shipment of equipment for approval. |
| 2 | The whole system shall be accordance to standard, confirm to high standard of engineering design and design and workmanship in all respect. |
| 3 | The vender shall make all possible efforts to comply strictly with the requirements of these specifications, compliance sheet , data sheeta as mentioned. |
| 4 | Incase, of any deviations are considered essential by the vender after making all possible efforts, efforts, these shall be separately listed along offer/technical submittal under " LIST OF DEVIATIONS/EXCEPTIONS TO THE ENQUIRY" for consideration and approval with cross reference reference and proper reason for the deviations/exception. |
| 5 | Compliance to this specification shall not relief the vender from the responsibility of supplying the equipment and auxiliaries of proper design, material and workmanship to meet the meet the specified operating conditions. |
| 6 | In case of any requirement of additional instruments, controls, safety devices or any other auxiliaries or accessories for safe, smooth and trouble free operation of the equipment vender shall include the same in scope of supply and give reason with in offer / technical submittal. |
| 7 | Vender shall submit all the certifications along offer/technical submittal. |

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# TECHNICAL DATA SHEET FOR HOT WATER HEATER

| S.NO | ITEM | UNIT | DESCRIPTION FOR HOT WATER HEATE |
|---|---|---|---|
| 1 | Unit Tag No | | HTR-1 |
| 2 | Quantity | | 1 |
| 3 | Space Served | | Main Building S.B.P |
| 4 | Equipment Installed at | | 2nd Basement, Plant Room |
| 5 | Type | | Hot Water Heater for Space Heating<br>Flexible Tube. Single Piece Unit |
| 6 | Ambiant Conditions | | Summer: 108.0° F db,86.0° F wb, 39.8 % RH<br>Monsoon : 95.0° F db, 85.0 ° F wb, 66.85 % RH<br>Winter : 38.0° F db, 30% RH |
| 7 | Altitude (Elevation above Sea Sea Level) | Ft | 756.6 |
| 8 | Latitude | Degree | 31.166° North |
| 9 | Longitude | Degree | 74.195° East |
| 10 | Total Heating Capacity | MBH | 1,453 |
| 11 | Hot Water Flow Rate | US-Gpm | 290 |
| 12 | Hot Water Temp In/Out | °F | 120.0/130.0 |
| 13 | Fuel | | Natural Gas/HSD Oil |
| 14 | Burner | | Forced Draft/Duel Fuel |
| 15 | Power | V-Ph-Hz | 380-3-50 |
| 16 | Electrical motors protection class | | Least IP44/NEMA 1 or equivalent. |

**Note;**

| | |
|---|---|
| 1 | The hot water heater package shall be factory tested and all test certificate shall be provided/ submitted prior to shipment. |
| 2 | The whole system shall be accordance to standard, confirm to high standard of engineering design design and workmanship in all respect. |
| 3 | The vender shall make all possible efforts to comply strictly with the requirements of these specifications, compliance sheet , data sheeta as mentioned. |
| 4 | Incase, of any deviations are considered essential by the vender after making all possible efforts, efforts, these shall be separately listed along offer/technical submittal under " LIST OF DEVIATIONS/EXCEPTIONS TO THE ENQUIRY" for consideration and approval with cross reference and proper reason for the deviations/exception. |
| 5 | Compliance to this specification shall not relief the vender from the responsibility of supplying the equipment and auxiliaries of proper design, material and workmanship to meet the meet the specified operating conditions. |
| 6 | In case of any requirement of additional instruments, controls, safety devices or any other auxiliaries or accessories for safe, smooth and trouble free operation of the equipment vender shall include the same in scope of supply and give reason within offer / technical submittal. |
| 7 | Vender shall submit all the certifications along offer/technical submittal. |

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## TECHNICAL DATA SHEET FOR COOLING TOWER

| S.NO | ITEM | UNIT | DESCRIPTION FOR COOLING TOWER |
|---|---|---|---|
| 1 | Unit Tag No | | CT-1 |
| **2** | Quantity | | 1 |
| 3 | Space Served | | Main Building S.B.P |
| 4 | Equipment Installed at | | ROOF |
| 5 | Code and Standard for Cooling Tower | :<br>:<br>:<br>: | Cooling Tower Institute (USA)<br>ASHRAE Application<br>OSHA<br>FM Global |
| 6 | Type | | CTI Certified & Approved Brand,<br>Open Circuit Cooling Tower, Induced Draft Cross Flow. |
| 7 | Configuration | | Rectangular, Side Intake, Top Discharge.<br>FRP Construction with UV resistant Polyester Resin. |
| 8 | Ambiant Conditions | | Summer: 108° F db,86° F wb<br>Monsoon : 95.0° F db, 85.0 ° F wb<br>Winter : 38° F db, 30% RH |
| 9 | Altitude (Elevation above Sea Sea Level) | Ft | 756.6 |
| 10 | Latitude | Degree | 31.166° North |
| 11 | Longitude | Degree | 74.195° East |
| 12 | Ambient Pressure | | 29.92 inches(760mm) Column of mercury<br>101.33 Kilopascals |
| 13 | Wind Velocity | | Summer : 13Km/hr<br>Winter : 19Km/hr |
| 14 | Cooling Water Flow Rate | US-Gpm | 910 |
| 15 | Air Entering Wet Bulb Temp | °F | 84.2 |
| 16 | Cooling Water Temp In/Out | °F | 91.0/101.0 |
| 17 | Range | °C | 5.5 |
| 18 | Approach | °C | 5 |
| 20 | Drift Losses | | Not more than 0.1% of circulated water. |
| 21 | Installed at | | Roof Top, Exposed to Weather |
| 22 | Application | | For Chiller (CH-1) |
| | Type of Fan | | Belt Drive, Propeller/Axial |
| 23 | Fan | | Variable speed Fan |
| 21 | Controls | | Micoprocessor based Digital controlled Fan rpm/on-off controlled through sensing of LWT (Leaving Water Temperature) capable to interface with BMS/SCADA |

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| S.NO | ITEM | UNIT | DESCRIPTION FOR COOLING TOWER |
|---|---|---|---|
| 22 | Electrical Characteristics | Ph/V/Hz | +/- 5 % 400 V, 3 Phase, 50 Hz. |
| 23 | Electric Motor | | TEFC, Max 960 rpm, IP-55 Protection & Class F Insulation. |
| 24 | Metal Structure covered with FRP | | Hot Dipped Galvanized Steel Structure |
| 25 | Metal Parts exposed to weather | No | Hot Dipped Galvanized |
| 26 | Hardware, Nuts & Bolts | | Stainless Steel (S.S-316) |
| 27 | Water Quality Management | | Semi-Automatic |
| 33 | Operating hours/year | Hr | 7,488 |
| 34 | Electrical motors protection class | | Least IP44/NEMA 1 or equivalent. |
| 35 | Inspection and Testing | | Performance shall be rated in accordance to CTI. |

**Note;**

| | |
|---|---|
| 1 | The Cooling Tower shall be factory tested and all test certificate shall be provided along shipment. |
| 2 | The whole system shall be accordance to standard, confirm to high standard of engineering design design and workmanship in all respect. |
| 3 | The vender shall make all possible efforts to comply strictly with the requirements of these specifications, compliance sheet , data sheet a as mentioned. |
| 4 | Incase, of any deviations are considered essential by the vender after making all possible efforts, efforts, these shall be separately listed along offer/technical submittal under " LIST OF DEVIATIONS/EXCEPTIONS TO THE ENQUIRY" for consideration and approval with cross reference reference and proper reason for the deviations/exception. |
| 5 | Compliance to this specification shall not relief the vender from the responsibility of supplying the equipment and auxiliaries of proper design, material and workmanship to meet the meet the specified operating conditions. |
| 6 | In case of any requirement of additional instruments, controls, safety devices or any other auxiliaries or accessories for safe, smooth and trouble free operation of the equipment vender shall include the same in scope of supply and give reason within offer / technical submittal. |
| 7 | Vender shall submit all the certifications along offer/technical submittal. |

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## TECHNICAL DATA SHEET FOR AIR HANDLING UNITS

| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 1** | **AHU- 2** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | GROUND FLOOR<br>Lift Lobby, Lobby, ATM, Hall FBR Room, Days Receipt Counter, UPS+Data, Office | GROUND FLOOR<br>Lift Lobby,Public Lobby,Hall Reception, SEC, Bank Payment Counter, Day Voult |
| **Equipment Installed at** | | AHU-Room-1 | AHU-Room-2 |
| Supply Air Flow | CFM | 12,785.0 | 12,885.0 |
| Fresh Air | CFM/Temp | 835/73.4 ºF | 890/73.4 ºF |
| Return Air Flow | CFM | 11,950.0 | 11,995.0 |
| External Static Pressure | in-$H_2O$ | 1.66 | 1.68 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Cooling Capacity | BTU/Hr | 294,570.00 | 294,780.00 |
| Total Sensible Capacity | BTU/Hr | 265,775.00 | 266,018.00 |
| Coil Entering- Air Temp DB/WB | Deg ºF | 73.4/64.1 | 73.4/64.1 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 53.3/52.7 | 53.3/52.7 |
| Supply- Air Temp DB / WB | Deg ºF | 53.5/52.8 | 53.5/52.8 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44/54 | 44/54 |
| Chilled Water Flow | GPM | 58.90 | 58.95 |
| Connection Size | Inches | 2.5 (65 mm) | 2.5 (65 mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **Re-Heating** | | | |
| Total Capacity | BTU/Hr | 42,804.18 | 43,138.95 |
| Electrical Capacity | Kw | 12.50 | 12.60 |
| Coil Entering- Air Temp DB | Deg ºF | 53.5 | 53.5 |
| Coil Leaving- Air Temp DB | Deg ºF | 56.5 | 56.5 |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 6,400.0 | 6,450.0 |
| Fresh Air | CFM/Temp | 600/38.0 ºF | 650/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.22 | 1.23 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 178,143.00 | 178,350.00 |
| Coil Entering- Air Temp DB | Deg ºF | 68.0 | 68.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 95.3 | 95.3 |
| Supply- Air Temp DB | Deg ºF | 94.0 | 94.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 35.62 | 35.67 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 1** | **AHU- 2** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 3 | 3 |
| Unit Section / Module | | 1-2-3-4,7 | 1-2-3-4,7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | Class-Qty | EU-4 (12 Nos) | EU-4 (12 Nos) |
| | Size | 24"x24"x2" | 24"x24"x2" |
| | Type | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| Sec Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | kW | 7.5 | 7.5 |
| Motor Protection / Efficiency | | IP 55 with Class 'F' Insulation / IE3 | |

**Note:**

| **A. Unit Type:** | **B. Unit Configuration:** | **C.Unit Section & Module:** |
|---|---|---|
| 1. Horizontal Ceiling Suspended | 1. Front Discharge & Rear Intake | 1. Mixing Box |
| 2. Horizontal Floor Mounted | 2.Top Dischcharge & Rear Intake | 2. Filter Plenum for E-4 |
| 3. Vertcal Floor Mounted | 3.Top Discharge& Top Intake | 3. Ist Step Cooling Coil. |
| | 4. Bottom Discharge & Bottom Intake | 4. Pvc, Drop Eliminator. |
| | 5. Side Discharge & Side Intake | 5. 2nd Step DX Cooling Coil. |
| | | 6. Re-heating Coil. |
| | | 7. Blower Fan. |
| | | 8. Perforated Diffusor |
| | | 9. Filter Plenum for E-9 |

**NOTE.**

A- Motor power input to be provided by the manufacturer alongwith data sheet.
B- Computer selection of each AHU to be submitted by the suppliers for consultant approval.
C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing.
D- Motor HP shall be selected at least 120% of required BHP.
E- All the Dampers shall be equiped with factory fitted motors.
F- Coil section shall have Drops Eliminator formed by special PVC or S.S

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 3** | **AHU- 4** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | GROUND FLOOR<br>Office, meeting Room | GROUND FLOOR<br>Visiters Area |
| **Equipment Installed at** | | AHU-Room-3 | AHU-Room-4 |
| **Cooling Mode** | | | |
| Supply Air Flow | CFM | 2,800.0 | 2,060.0 |
| Fresh Air | CFM/Temp | 250.0 | 200.0 |
| Return Air Flow | CFM | 2,550.0 | 1,860.0 |
| External Static Pressure | in-$H_2O$ | 1.10 | 1.12 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Cooling Capacity | BTU/Hr | 76,825.00 | 46,800.00 |
| Total Sensible Capacity | BTU/Hr | 71,820.00 | 39,780.00 |
| Coil Entering- Air Temp DB / WB | Deg ºF | 73.6/64.2 | 75.4/63.5 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 50.65/49.8 | 54.5/54.0 |
| Supply- Air Temp DB / WB | Deg ºF | 51.25/49.9 | 55.8/54.8 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44/54 | 44/54 |
| Chilled Water Flow | GPM | 15.36 | 9.36 |
| Connection Size | Inches | 2.0 (50 mm) | 1.25 (32 mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **Re-Heating** | | | |
| Total Capacity | BTU/Hr | 17,690.0 | |
| Electrical Heating Capacity | Kw | 5.2 | |
| Coil Entering- Air Temp DB | Deg ºF | 51.3 | |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 56.5 | |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 1,800.0 | 1,000.0 |
| Fresh Air | CFM/Temp | 200/38.0 ºF | 110/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.20 | 1.10 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 64,160.00 | 37,440.00 |
| Coil Entering- Air Temp DB | Deg ºF | 68.0 | 68.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 95.3 | 95.3 |
| Supply- Air Temp DB | Deg ºF | 93.5 | 94.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 12.80 | 7.48 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 3** | **AHU- 4** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 3 | 3 |
| Unit Section / Module | | 1-2-3-4,7 | 1-2-3-4,7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | Class-Qty | EU-4 (1 Nos) | EU-4 (12 Nos) |
| | Size | 24"x24"x2" | 24"x24"x2" |
| | Type | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| Sec Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | kW | 4.0 | |
| Motor Protection / Efficiency | | IP 55 with Class 'F' Insulation / IE3 | |

**Note:**

| **A. Unit Type:** | **B. Unit Configuration:** | **C.Unit Section & Module:** |
|---|---|---|
| 1. Horizontal Ceiling Suspended | 1. Front Discharge & Rear Intake | 1. Mixing Box |
| 2. Horizontal Floor Mounted | 2.Top Dischcharge & Rear Intake | 2. Filter Plenum for E-4 |
| 3. Vertcal Floor Mounted | 3.Top Discharge& Top Intake | 3. Ist Step Cooling Coil. |
| | 4. Bottom Discharge & Bottom Intake | 4. Pvc, Drop Eliminator. |
| | 5. Side Discharge & Side Intake | 5. 2nd Step DX Cooling Coil. |
| | | 6. Re-heating Coil. |
| | | 7. Blower Fan. |
| | | 8. Perforated Diffusor |
| | | 9. Filter Plenum for E-9 |

**NOTE.**

A- Motor power input to be provided by the manufacturer alongwith data sheet.
B- Computer selection of each AHU to be submitted by the suppliers for consultant approval.
C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing.
D- Motor HP shall be selected at least 120% of required BHP.
E- All the Dampers shall be equiped with factory fitted motors.
F- Coil section shall have Drops Eliminator formed by special PVC or S.S

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 5** | **AHU- 6** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | MEZZANINE FLOOR<br>Visiting Executive, CM Chamber<br>Reception Waiting<br>Fift Lobby, Sitting Area | MEZZANINE FLOOR<br>Coin Section, Office<br>Main Conference Room<br>Fift Lobby, Sitting Area |
| **Equipment Installed at** | | AHU-Room-5 | AHU-Room-6 |
| Supply Air Flow | CFM | 11,080.0 | 12,750.0 |
| Fresh Air | CFM/Temp | 800 | 800.0 |
| Return Air Flow | CFM | 10,280 | 11,950.0 |
| External Static Pressure | in-$H_2O$ | 1.30 | 1.30 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Cooling Capacity | BTU/Hr | 275,258.00 | 316,822.00 |
| Total Sensible Capacity | BTU/Hr | 247,336.00 | 284,684.00 |
| Coil Entering- Air Temp DB / WB | Deg ºF | 73.6/64.2 | 73.6/64.2 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 50.4/49.8 | 50.4/49.8 |
| Supply Air Temp DB / WB | Deg ºF | 50.6/49.9 | 50.6/49.9 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44/54 | 44/54 |
| Chilled Water Flow | GPM | 55.00 | 63.36 |
| Connection Size | Inches | 2-1/2" (65mm) | 2-1/2" (65mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **Re-Heating** | | | |
| Total Capacity | BTU/Hr | 67,011.8 | 77,112.0 |
| Electrical Heating Capacity | Kw | 19.6 | 22.61 |
| Coil Entering- Air Temp DB | Deg ºF | 50.6 | 50.6 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 56.0 | 56.0 |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 4,800.0 | 5,015.0 |
| Fresh Air | CFM/Temp | 550/38.0 ºF | 650/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.26 | 1.20 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1,200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 166,735.00 | 168,735.00 |
| Coil Entering- Air Temp DB | Deg ºF | 68.0 | 68.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 95.3 | 95.3 |
| Supply- Air Temp DB | Deg ºF | 94.0 | 94.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 33.34 | 33.74 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 5** | **AHU- 6** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 3 | 3 |
| Unit Section / Module | | 1-2-3-4,7 | 1-2-3-4,7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | Class-Qty | EU-4 (14 Nos) | EU-4 (12 Nos) |
| | Size | 24"x24"x2" | 24"x24"x2" |
| | Type | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| Sec Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | kW | 7.5 | 10.00 |
| Motor Protection / Efficiency | | IP 55 with Class 'F' Insulation / IE3 | |
| **Note:** | | | |
| **A. Unit Type:** | **B. Unit Configuration:** | | **C.Unit Section & Module:** |
| 1. Horizontal Ceiling Suspended | 1. Front Discharge & Rear Intake | | 1. Mixing Box |
| 2. Horizontal Floor Mounted | 2.Top Dischcharge & Rear Intake | | 2. Filter Plenum for E-4 |
| 3. Vertcal Floor Mounted | 3.Top Discharge& Top Intake | | 3. Ist Step Cooling Coil. |
| | 4. Bottom Discharge & Bottom Intake | | 4. Pvc, Drop Eliminator. |
| | 5. Side Discharge & Side Intake | | 5. 2nd Step DX Cooling Coil. |
| | | | 6. Re-heating Coil. |
| | | | 7. Blower Fan. |
| | | | 8. Perforated Diffusor |
| | | | 9. Filter Plenum for E-9 |
| **NOTE.** | | | |
| A- Motor power input to be provided by the manufacturer alongwith data sheet. | | | |
| B- Computer selection of each AHU to be submitted by the suppliers for consultant approval. | | | |
| C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing. | | | |
| D- Motor HP shall be selected at least 120% of required BHP. | | | |
| E- All the Dampers shall be equiped with factory fitted motors. | | | |
| F- Coil section shall have Drops Eliminator formed by special PVC or S.S | | | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 7** | **AHU- 8** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | FIRST FLOOR<br>Day Care, Emergency Room<br>Fe-male Common Room,Passage<br>Male Doctor, Lift Lobby | FIRST FLOOR<br>Lift Lobby, Office<br>Assistant Cubicals<br>IT Staff, UPS, UPS |
| **Equipment Installed at** | | AHU-Room-7 | AHU-Room-8 |
| Supply Air Flow | CFM | 10,680.0 | 11,390.0 |
| Fresh Air | CFM/Temp | 672.0 | 678.0 |
| Return Air Flow | CFM | 10,008.0 | 10,712.0 |
| External Static Pressure | in-$H_2O$ | 1.30 | 1.30 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Cooling Capacity | BTU/Hr | 279,700.00 | 282,411.00 |
| Total Sensible Capacity | BTU/Hr | 257,240.00 | 259,825.60 |
| Coil Entering- Air Temp DB / WB | Deg ºF | 73.6/64.2 | 73.6/64.2 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 49.4/49.0 | 50.7/50.1 |
| Supply- Air Temp DB / WB | Deg ºF | 49.8/49.4 | 51.0/50.8 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44/54 | 44/54 |
| Chilled Water Flow | GPM | 55.93 | 56.50 |
| Connection Size | Inches | 2.5 (65mm) | 2.5 (65 mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **Re-Heating** | | | |
| Total Capacity | BTU/Hr | 71,513.20 | 60,275.88 |
| Electrical Capacity | Kw | 20.97 | 17.70 |
| Coil Entering- Air Temp DB | Deg ºF | 49.8/49.4 | 51.0/50.8 |
| Coil Leaving- Air Temp DB | Deg ºF | 56.94 | 56.50 |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 4,900.0 | 5,135.0 |
| Fresh Air | CFM/Temp | 458/38.0 ºF | 542/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.20 | 1.26 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 168,083.00 | 170,083.00 |
| Coil Entering- Air Temp DB | Deg ºF | 68.0 | 68.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 95.3 | 95.3 |
| Supply- Air Temp DB | Deg ºF | 94.0 | 94.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 33.61 | 34.00 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 7** | **AHU- 8** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 3 | 3 |
| Unit Section / Module | | 1-2-3-4,7 | 1-2-3-4,7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | Class-Qty | EU-4 (12 Nos) | EU-4 (12 Nos) |
| | Size | 24"x24"x2" | 24"x24"x2" |
| | Type | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| Sec Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | kW | 7.5 | 10.00 |
| Motor Protection / Efficiency | | IP 55 with Class 'F' Insulation / IE3 | |

**Note:**

| **A. Unit Type:** | **B. Unit Configuration:** | **C.Unit Section & Module:** |
|---|---|---|
| 1. Horizontal Ceiling Suspended | 1. Front Discharge & Rear Intake | 1. Mixing Box |
| 2. Horizontal Floor Mounted | 2.Top Dischcharge & Rear Intake | 2. Filter Plenum for E-4 |
| 3. Vertcal Floor Mounted | 3.Top Discharge& Top Intake | 3. Ist Step Cooling Coil. |
| | 4. Bottom Discharge & Bottom Intake | 4. Pvc, Drop Eliminator. |
| | 5. Side Discharge & Side Intake | 5. 2nd Step DX Cooling Coil. |
| | | 6. Re-heating Coil. |
| | | 7. Blower Fan. |
| | | 8. Perforated Diffusor |
| | | 9. Filter Plenum for E-9 |

**NOTE.**

A- Motor power input to be provided by the manufacturer alongwith data sheet.
B- Computer selection of each AHU to be submitted by the suppliers for consultant approval.
C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing.
D- Motor HP shall be selected at least 120% of required BHP.
E- All the Dampers shall be equiped with factory fitted motors.
F- Coil section shall have Drops Eliminator formed by special PVC or S.S

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 09** | **AHU- 10** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | 2nd Basement<br>Passage,Hall,Police Guard<br>Lobby, Exam-Hall.1, Exam-Hall.2<br>Office Seating | 2nd Basement<br>Vault Area |
| **Equipment Installed at** | | Second Basement | |
| Supply Air Flow | CFM | 10,280.0 | 12,000.0 |
| Fresh Air | CFM/Temp | 1082 /108 ºF | 1,200 /108 ºF |
| Return Air Flow | CFM | 9,198.0 | 11,800.0 |
| External Static Pressure | in-$H_2O$ | 1.34 | 1.41 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500.0 | |
| Total Cooling Capacity | BTU/Hr | 338,900.0 | 415,300.0 |
| Total Sensible Capacity | BTU/Hr | 248,100.0 | 302,700.0 |
| Coil Entering- Air Temp DB / WB | Deg ºF | 77.0/65.2 | 77.6/64.8 |
| Coil Leaving- Air Temp DB / WB | Deg ºF | 53.9/53.0 | 54.2/53.1 |
| Supply- Air Temp DB / WB | Deg ºF | 54.8/53.8 | 55.5/54.5 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 45/55 | |
| Chilled Water Flow | GPM | 67.78 | 83.06 |
| Connection Size | Inches | 2-1/2" (65 mm) | 3" (80mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **Re-Heating** | | | |
| Source of Heating | | Electrical | Electrical |
| Heating Capacity | MBH | 49,961.00 | 64,800.00 |
| Entering Air Temperature DB / WB | Deg ºF | 54.8/53.8 | 55.5/54.5 |
| Leaving Air Temperature DB / WB | Deg ºF | 59.5/55.0 | 60.5/55.5 |
| Electrical Heater | Kw | 14.5 | 19 |
| Stages | Nos | 2 | 2 |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 5,598.0 | 6,000.0 |
| Fresh Air | CFM/Temp | 555/38.0 ºF | 1000/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.32 | 1.41 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 155,651.00 | 103,536.00 |
| Coil Entering- Air Temp DB | Deg ºF | 68.0 | 68.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 95.3 | 95.3 |
| Supply- Air Temp DB | Deg ºF | 94.0 | 94.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 31.13 | 20.76 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |

| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **AHU- 09** | **AHU- 10** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 3 | 3 |
| Unit Section / Module | | 1-2-3-4,7 | 1-2-3-4,7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | | EU-4 (12 Nos) | EU-4 (14 Nos) |
| | Class-Qty | 24"x24"x2" | 24"x24"x2" |
| | Size | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Type | NIL | NIL |
| | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| Sec Filter & Plenum | Type | NIL | NIL |
| | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | | | |
| Motor Protection / Efficiency | kW | IP 55 with Class 'F' Insulation / IE3 | |

**Note:**

| **A. Unit Type:** | **B. Unit Configuration:** | **C.Unit Section & Module:** |
|---|---|---|
| 1. Horizontal Ceiling Suspended | 1. Front | 1. Mixing Box |
| 2. Horizontal Floor Mounted | 2.Top | 2. Filter Plenum for E-4 |
| 3. Vertcal Floor Mounted | 3.Top | 3. Ist Step Cooling Coil. |
| | 4. Bottom | 4. Pvc, Drop Eliminator. |
| | 5. Side | 5. 2nd Step DX Cooling Coil. |
| | | 6. Re-heating Coil. |
| | | 7. Blower Fan. |
| | | 8. Perforated Diffusor |
| | | 9. Filter Plenum for E-9 |

**NOTE.**

A- Motor power input to be provided by the manufacturer alongwith data sheet.
B- Computer selection of each AHU to be submitted by the suppliers for consultant approval.
C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing.
D- Motor HP shall be selected at least 120% of required BHP.
E- All the Dampers shall be equiped with factory fitted motors.
F- Coil section shall have Drops Eliminator formed by special PVC or S.S

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## TECHNICAL DATA SHEET FOR AIR HANDLING UNITS

| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **FA-AHU-1** | **FA-AHU-2** |
| Quantity | Nos | **1** | **1** |
| **Space Served** | | ROOF-TOP<br>For Fresh Air Supply | ROOF TOP<br>For Fresh Air Supply |
| **Equipment Installed at** | | ROOF-TOP | ROOF-TOP |
| Supply Air Flow | CFM | 2,313.0 | 2,612.0 |
| Fresh Air | CFM | 2,313.0 | 2,612.0 |
| Return Air Flow | CFM | NIL | NIL |
| External Static Pressure | in-$H_2O$ | 0.80 | 0.80 |
| Max. Face Outlet Velocity | FPM | 1,500 | 1500 |
| Max. Sound Level from 1 meter | dB | 55 | 55 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Chilled Water Cooling Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Cooling Capacity | BTU/Hr | 246,066.00 | 277,874.00 |
| Total Sensible Capacity | BTU/Hr | 118,666.00 | 143,868.00 |
| Entering Air Temperature (Summer DB / WB) | Deg ºF | 108/86 | 108/86 |
| Entering Air Temperature (Monsoon DB / WB) | Deg ºF | 95/85 | 95/85 |
| Leaving Air Temperature DB / WB | Deg ºF | 57.0/55.7 | 57.0/55.7 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44/54 | 44/54 |
| Chilled Water Flow | GPM | 49.21 | 55.57 |
| Connection Size | Inches | 2-1/2" (65 mm) | 2-1/2" (65 mm) |
| Max. Water Velocity | FPM | 15 | 15 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Cooling Coil (Tube / Fins) | | Copper / Alumunium | |
| | | | |
| **RE-Heating Coil** | | | |
| Max. Coil Face Velocity | FPM | 500 | |
| Total Heating Capacity | BTU/Hr | 40,967.85 | 46,263.00 |
| Entering Air Temperature (DB / WB) | Deg ºF | 57.3/56.7 | 57.3/56.7 |
| Leaving Air Temperature DB | Deg ºF | 73.4/62.5 | 73.4/62.5 |
| Electric Heating Coil Capacity | KW | 13.0 | 15.0 |
| No of Stages | Nos | Min-2 | Min-2 |
| | | | |
| **Heating Mode** | | | |
| Supply Air Flow | CFM | 1,725.0 | 1,925.0 |
| Fresh Air | CFM/Temp | 1,725/38.0 ºF | 1,925/38.0 ºF |
| External Static Pressure | in-$H_2O$ | 1.22 | 1.23 |
| Max. Face Outlet Velocity | FPM | 1,200 | 1200 |
| Altitude Above Mean Sea Level | Ft | 756.6 | |
| | | | |
| **Hot Water Heating Coil** | | | |
| Total Heating Capacity | BTU/Hr | 59,616.00 | 66,528.00 |
| Coil Entering- Air Temp DB | Deg ºF | 38.0 | 38.0 |
| Coil Leaving- Air Temp DB | Deg ºF | 70.3 | 70.3 |
| Supply- Air Temp DB | Deg ºF | 69.0 | 69.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 130/120 | 130/120 |
| Hot Water Flow | GPM | 11.92 | 13.30 |
| Max.Water Pressure Drop | Ft-$H_2O$ | 2.5 | 2.5 |
| Max. Fin Spacing per inch | Nos | 10 | 10 |
| Heating Coil (Tube / Fins) | | Copper / Alumunium | |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **FA-AHU-1** | **FA-AHU-2** |
| Quantity | Nos | **1** | **1** |
| **Unit Construction** | | | |
| Type of Unit | | 2 | 2 |
| Unit Configuration | | 1 | 3 |
| Unit Section / Module | | 1-2-9-4-6-7 | 1-2-9-4-6-7 |
| Skins | | Double | Double |
| Insulation thickness | Inch | 2" | 2" |
| Outer Wall thickness / Material | SWG | 20 / G.I + Paint | 20 / G.I + Paint |
| Inner Wall thickness / Material | SWG | 24 / G.I | 24 / G.I |
| Drive | | **Direct Driven Plug Fan with VFD** | |
| Return Filter & Plenum | Class-Qty | EU-4 (8 Nos) | EU-4 (6 Nos) |
| | Size | 24"x24"x2" | 24"x24"x2" |
| | Type | Allu-Washable, Pleated | Allu-Washable, Pleated |
| Pr Filter & Plenum | Class-Qty | EU-6 (8 Nos) | EU-6 (6 Nos) |
| | Size | 24"x24"x22" | 24"x24"x22" |
| | Type | Bag Type Filter | Bag Type Filter |
| Sec Filter & Plenum | Class-Qty | NIL | NIL |
| | Size | NIL | NIL |
| | Type | NIL | NIL |
| Terminal Filter with Housing | Class Filter size | Nil | Nil |

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| ITEM | Unit | DESCRIPTION FOR AIR HANDLING UNITS | |
|---|---|---|---|
| Unit Tag No. | | **FA-AHU-1** | **FA-AHU-2** |
| Quantity | Nos | **1** | **1** |
| **Electrical Data** | | 3 PH - 380 / 420 V, 50Hz | |
| Motor | kW | | |
| Motor Protection, | | IP 55 with Class 'F' Insulation | |
| **Note:** | | | |
| **A. Unit Type:** | **B. Unit Configuration:** | **C.Unit Section & Module:** | |
| 1. Horizontal Ceiling Suspended | 1. Front Discharge & Rear Intake | 1. Mixing Box | |
| 2. Horizontal Floor Mounted | 2.Top Dischcharge & Rear Intake | 2. Filter Plenum for E-4 | |
| 3. Vertical Floor Mounted | 3.Top Discharge& Top Intake | 3. Chilled Water Cooling Coil. | |
| | 4. Bottom Discharge & Bottom Intake | 4. Pvc, Drop Eliminator. | |
| | 5. Side Discharge & Side Intake | 5. 2nd Step DX Cooling Coil. | |
| | | 6. Re-heating Coil. | |
| | | 7. Blower Fan. | |
| | | 8. Perforated Diffusor | |
| | | 9. Filter Plenum for E-6 | |

**NOTE.**

A- Motor power input to be provided by the manufacturer alongwith data sheet.
B- Computer selection of each AHU to be submitted by the suppliers for consultant approval.
C- Ext. Static Pressure shown is Tantative. Actual Ext. Static Pressure shall be Calculated by the contractor on basis of approved shop drawing.
D- Motor HP shall be selected at least 120% of required BHP.
E- All the Dampers shall be equiped with factory fitted motors.
F- Coil section shall have Drops Eliminator formed by special PVC or S.S

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## Schedule of Fan Coil Units

| ITEM | Unit | | |
|---|---|---|---|
| Unit Tag No. | | FCU-2 | FCU-2.5 |
| Quantity | Nos | 2 | 1 |
| Space Served | | Engineering Room<br>Tel-Exchange<br>CC-TV Room | Tel-Exchange |
| **FAN** | | | |
| Supply Air Flow | CFM | 800 | 1000 |
| Fresh Air | CFM | 40 | 50 |
| External Static Pressure | Inch.WG | 0.5 | 0.6 |
| Max. Fan Outlet Velocity | FPM | 1200 | 1200 |
| Max. Coil Face Velocity | FPM | 450 | 450 |
| Max. Sound Level from 1 meter | dB | 45 | 50 |
| **COOLING COIL (TUBES/FINS)** | | | |
| Total Cooling Capacity | BTU / Hr | 24,000 | 30,000 |
| Sensible Capacity | BTU / Hr | X | X |
| Entering Air Temperature DB / WB | Deg ºF | 75.2 / 64.1 | 75.5 / 64.3 |
| Chilled Water Ent. / Lvg. Temp. | Deg ºF | 44 / 54 | 44 / 55 |
| Chilled Water Flow | US GPM | 4.8 | 6.0 |
| Max. Water Velocity | FPM | 2.5 | 2.5 |
| Max. Water Pressure Drop | Ft. WG | 10.0 | 10.0 |
| Max. Fin Spacing Per inch | | 10.0 | 10.0 |
| Cooling Coil (Tubs/Fins) | | | |
| **HEATING COIL (TUBES/FINS)** | | | |
| Total Cooling Capacity | BTU / Hr | 18,000.0 | 24,600.0 |
| Hot Water Ent. / Lvg. Temp. | Deg ºF | 120 / 130 | 120 / 130 |
| Hot Water Flow | US GPM | 3.6 | 4.9 |
| Max. Water Velocity | FPM | 2.5 | 2.5 |
| Max. Water Pressure Drop | Ft. WG | 10.0 | 10.0 |
| Heating Coil (Tubs/Fins) | | | |
| **UNIT CONSTRUCTION** | | | |
| Type of Unit | | C.C.D | C.C.D |
| Drive | | | |
| **ACCESSORIES** | Lot | | |
| **ELECTRICAL DATA** | | | |
| Motor Input | W | | |
| Motor Type | | | |

**Note:**

**A. Unit Type:**

1. C.C.D = Ceiling concealed ducted type unit
2. C.S.D = Ceiling suspended Decorative Type unit
3. W.M.D = Wall Mounted Decorative Type unit

A- Motor power input to be provided by the manufacturer alongwith data sheet.

B- Computer selection of each FCU to be provided by the suppliers for Consultant approval.

# Schedule of Split Type AC Units

Sheet-1

| ITEM | Unit | DESCRIPTION | | |
|---|---|---|---|---|
| Unit Tag No. | | AC-1 | AC-1.5 | AC-2 |
| Type | | Inverter Reversible Type, HEAT/COOL | | Cooling Only |
| Ambient Condition | °F | Summer DB/WB: 108 °F/ 85 °F<br>Monsoon DB/WB: 95 °F/ 85 °F | | |
| Quantity | Nos | 4 | 4 | 6 |
| Space Served | | Employ-Entrance Room | Gate Office Mezzanine | UPS & Data Cabinet G.F |
| | | Employ-Entrance-Lobby | Floor, Security Staff 1 &2 | UPS & Data Cabinet M.F |
| | | | | UPS & Data Cabinet F.F |
| | | | | |
| **FAN** | | | | |
| Supply Air Flow | CFM | 350 | 700 | 700 |
| External Static Pressure | Inch.WG | Free | | |
| Max. Fan Outlet Velocity | FPM | Standard | | |
| Max. Sound Level from 1 meter | dB | 40 | | |
| | | | | |
| **COOLING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | 12,000 | 24,000 | 24,000 |
| Entering Air Temperature DB / WB | Deg ºF | 73.5 / 62.5 | | |
| Cooling Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **HEATING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | Standard | | Not Required |
| Entering Air Temperature DB / WB | Deg ºF | 70 | | NIL |
| Heating Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **Refrigerant** | | R410a | | |
| **UNIT CONSTRUCTION** | | | | |
| Type of Unit | | W.M.D | W.M.D | W.M.D |
| **ACCESSORIES** | Lot | 2- Isolating liquid Line Valve,Dryer, Liqvid Line Glass, Remote thermostat with washable Syn. Filter | | |
| **ELECTRICAL DATA** | | | | |
| Motor Input | W | 1 PH - 220 / 240 V, 50Hz | | |
| Motor Type | | Single Phase, three speed, PSC, Closed type with overload protection | | |

**Note:**

**A. Unit Type:**

1. C.C.D = Ceiling concealed ducted type unit
2. C.S.D = Ceiling suspended Decorative Type unit
3. W.M.D = Wall Mounted Decorative Type unit

A- Motor power input to be provided by the manufacturer alongwith data sheet.

B- Computer selection of each AC Unit to be provided by the suppliers for Consultant approval.

C- AC Unit shall select on Medium Speed.

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# Schedule of Split Type AC Units

Sheet-2

| ITEM | Unit | DESCRIPTION | | |
|---|---|---|---|---|
| Unit Tag No. | | AC-1 | AC-1.5 | AC-2 |
| Type | | Inverter Reversible Type, HEAT/COOL | | |
| Ambient Condition | °F | Summer DB/WB: 108 °F/ 85 °F<br>Monsoon DB/WB: 95 °F/ 85 °F | | |
| Quantity | Nos | 3 | 5 | 3 |
| Space Served | | Office-2,3,4(Mezzanine Area) | Office-1(Mezzanine) | Meeting Room (Mezzanine Floor) |
| | | | | |
| **FAN** | | | | |
| Supply Air Flow | CFM | 350 | 450 | 700 |
| External Static Pressure | Inch.WG | Free | | |
| Max. Fan Outlet Velocity | FPM | Standard | | |
| Max. Sound Level from 1 meter | dB | 40 | | |
| | | | | |
| **COOLING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | 12,000 | 18,000 | 24,000 |
| Entering Air Temperature DB / WB | Deg ºF | 73.5 / 62.5 | | |
| Cooling Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **HEATING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | Standard | | Not Required |
| Entering Air Temperature DB / WB | Deg ºF | 70 | | NIL |
| Heating Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **Refrigerant** | | R410a | | |
| **UNIT CONSTRUCTION** | | | | |
| Type of Unit | . | C.C.C | C.C.C | C.C.C |
| **ACCESSORIES** | Lot | 2- Isolating liquid Line Valve,Dryer, Liqvid Line Glass, Remote thermostat with washable Syn. Filter | | |
| **ELECTRICAL DATA** | | | | |
| Motor Input | W | 1 PH - 220 / 240 V, 50Hz | | |
| Motor Type | | Single Phase, three speed, PSC, Closed type with overload protection | | |

**Note:**

**A. Unit Type:**

1. C.C.D = Celing concealed ducted type unit
2. C.S.D = Celing suspended Decorative Type unit
3. C.C.C = Celing concealed Cassette type unit
4. W.M.D = Wall Mounted Decorative Type unit

A- Motor power input to be provided by the manufacturer alongwith data sheet.

B- Computer selection of each AC Unit to be provided by the suppliers for Consultant approval.

C- AC Unit shall select on Medium Speed.

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# Schedule of Split Type AC Units

Sheet-3

| ITEM | Unit | DESCRIPTION | | |
|---|---|---|---|---|
| Unit Tag No. | | AC-3 | AC-4 | |
| Type | | Inverter Reversible Type, HEAT/COOL | | |
| Ambient Condition | °F | Summer DB/WB: 108 °F/ 85 °F<br>Monsoon DB/WB: 95 °F/ 85 °F | | |
| Quantity | Nos | 2 | 2 | |
| Space Served | | CM Chamber<br>Visiting Executive Office<br>(Mezzanine Floor) | Conference Room<br>(Mezzanine Floor) | |
| | | | | |
| **FAN** | | | | |
| Supply Air Flow | CFM | 900 | 1200 | |
| External Static Pressure | Inch.WG | Free | | |
| Max. Fan Outlet Velocity | FPM | Standard | | |
| Max. Sound Level from 1 meter | dB | 40 | | |
| | | | | |
| **COOLING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | 36,000 | 48,000 | |
| Entering Air Temperature DB / WB | Deg ºF | 73.5 / 62.5 | | |
| Cooling Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **HEATING COIL (TUBES/FINS)** | | | | |
| Total Cooling Capacity | BTU / Hr | Standard | | |
| Entering Air Temperature DB / WB | Deg ºF | 70 | | |
| Heating Coil (Tubs/Fins) | | Copper/Alumunim | | |
| | | | | |
| **Refrigerant** | | R410a | | |
| **UNIT CONSTRUCTION** | | | | |
| Type of Unit | . | C.C.C | C.C.C | |
| **ACCESSORIES** | Lot | 2- Isolating liquid Line Valve,Dryer, Liqvid Line Glass, Remote thermostat with washable Syn. Filter | | |
| **ELECTRICAL DATA** | | | | |
| Motor Input | W | 1 PH - 220 / 240 V, 50Hz | | |
| Motor Type | | Single Phase, three speed, PSC, Closed type with overload protection | | |

**Note:**

**A. Unit Type:**

1. C.C.D = Celing concealed ducted type unit
2. C.S.D = Celing suspended Decorative Type unit
3. C.C.C = Celing concealed Cassette type unit
4. W.M.D = Wall Mounted Decorative Type unit

A- Motor power input to be provided by the manufacturer alongwith data sheet.

B- Computer selection of each AC Unit to be provided by the suppliers for Consultant approval.

C- AC Unit shall select on Medium Speed.

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## Schedule of VRV AC System

| ITEM | Unit | DESCRIPTION | | | |
|---|---|---|---|---|---|
| Unit Tag No. | | AC-1 | AC-2 | AC-3 | AC-4 |
| Type | | VRV System, HEAT/COOL High-COP | | | |
| Ambient Condition | °F | Summer DB/WB: 108 °F/ 85 °F<br>Monsoon DB/WB: 95 °F/ 85 °F | | | |
| **In Door Unit** | | | | | |
| Space Served | | Room-1, G.Floor | GYM. F.F | Prayer. F.F | CCTV/BMS |
| Cooling Capacity | BTU / Hr | 18,000.00 | 30,000.00 | 36,000.00 | 24,000.00 |
| Air Flow | Cfm | 550.00 | 750.00 | 1,000.00 | 550.00 |
| ESP | in-$H_2O$ | Free | Free | 0.50 | Free |
| Type | | W.M.D | W.M.D | C.C.D | W.M.D |
| Space Served | | Bag Scan | GYM. F.F | Prayer. F.F | Security Officers |
| Cooling Capacity | BTU / Hr | 18,000.00 | 30,000.00 | 36,000.00 | 18,000.00 |
| Air Flow | Cfm | 550.00 | 750.00 | 1,000.00 | 550.00 |
| ESP | in-$H_2O$ | Free | Free | 0.50 | Free |
| Type | | W.M.D | W.M.D | C.CD | W.M.D |
| Space Served | | Entrance | FA-FCU GYM+PRYER | | Duty Room |
| Cooling Capacity | BTU / Hr | 12,000.00 | 423,100.00 | | 18,000.00 |
| Air Flow | Cfm | 350 | 450.00 | | 350 |
| ESP | in-$H_2O$ | Free | 0.80 | | Free |
| Type | | W.M.D | C.C.D | | W.M.D |
| Space Served | | Exit | | | |
| Cooling Capacity | BTU / Hr | 12,000.00 | | | |
| Air Flow | Cfm | 350.00 | | | |
| ESP | in-$H_2O$ | Free | | | |
| Type | | W.M.D | | | |
| Space Served | | 5 Ft Wide Passage | | | |
| Cooling Capacity | BTU / Hr | 12,000.00 | | | |
| Air Flow | Cfm | 350.00 | | | |
| ESP | in-$H_2O$ | Free | | | |
| Type | | W.M.D | | | |
| Entering Air Temperature DB / WB | Deg ºF | 75.4 ºF /63.5 ºF | | | |
| **Out Door Unit** | | | | | |
| Unit Tag No | | CU-1 | CU-2 | CU-3 | CU-4 |
| Total Cooling Capacity | BTU / Hr | 72,000.0 Approx | 84,000.0 Approx | 60,000.0 Approx | 60,000.0 Approx |
| Entering Air Temperature DB / WB | Deg ºF | Summer DB/WB: 108 °F/ 85 °F ,Monsoon DB/WB: 95 °F/ 85 °F | | | |
| Cooling Coil (Tubs/Fins) | | Copper/Alumunim | | | |
| **HEATING COIL (TUBES/FINS)** | | | | | |
| Total Cooling Capacity | BTU / Hr | Standard | | | |
| Entering Air Temperature DB / WB | Deg ºF | 70 | | | |
| Heating Coil (Tubs/Fins) | | Copper/Alumunim | | | |
| **ACCESSORIES** | Lot | 2- Isolating liquid Line Valve,Dryer, Liqvid Line Glass, Remote thermostat with washable Syn. Filter | | | |
| **ELECTRICAL DATA** | | | | | |
| Motor Input | W | 1 PH - 220 / 240 V, 50Hz | | | |
| Motor Type | | Single Phase, three speed, PSC, Closed type with overload protection | | | |

**Note:**

**A. Unit Type:**

1. C.C.D = Celing concealed ducted type unit
2. C.S.D = Celing suspended Decorative Type unit
3. W.M.D = Wall Mounted Decorative Type unit

A- Motor power input to be provided by the manufacturer alongwith data sheet.

B- Computer selection of each AC Unit to be provided by the suppliers for Consultant approval.

C- Indoor Unit shall select on Medium Speed.

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## Schedule of Pumps

| TAG | QTY #s | DISCHARGE US-Gpm | HEAD Ft | TYPE | SERVICE | VOLTS | PHASE | RPM | LOCATION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| **CHP. 1-2** | 2 | 644 | 80 | HORIZONTAL, SPLITCASE/END SUCTION BACK PULL OUT DESIGNED | FOR PR.CHILLED WATER CIRCULATION | 380 | 3 | 1450 | PLANT ROOM | BRONZE IMPELLER, S.S SHAFT, MECHANICAL SEAL, INTERIA BLOCK WITH 2" RUBBER PAD, MOTOR PROTECTION : IP54, INSULATION CLASS: F & SPACER COUPLING |
| **CHP. 3-4** | 2 | 644 | 129 | HORIZONTAL, SPLITCASE/END SUCTION BACK PULL OUT DESIGNED | FOR SEC.CHILLED WATER CIRCULATION | 380 | 3 | 2900 | PLANT ROOM | BRONZE IMPELLER, S.S SHAFT, MECHANICAL SEAL, INTERIA BLOCK WITH 2" RUBBER PAD, MOTOR PROTECTION : IP54, INSULATION CLASS: F & SPACER COUPLING |
| **CWP. 1-2** | 2 | 910 | 108 | HORIZONTAL, SPLITCASE/END SUCTION BACK PULL OUT DESIGNED | FOR CONDENSER WATER CIRCULATION | 380 | 3 | 1450 | PLANT ROOM | BRONZE IMPELLER, S.S SHAFT, MECHANICAL SEAL, INTERIA BLOCK WITH 2" RUBBER PAD, MOTOR PROTECTION : IP54, INSULATION CLASS: F & SPACER COUPLING |
| **HWP. 1-2** | 2 | 290 | 157 | HORIZONTAL, SPLITCASE/END SUCTION BACK PULL OUT DESIGNED | FOR HOT WATER CIRCULATION | 380 | 3 | 2900 | PLANT ROOM | BRONZE IMPELLER, S.S SHAFT, MECHANICAL SEAL, INTERIA BLOCK WITH 2" RUBBER PAD, MOTOR PROTECTION : IP54, INSULATION CLASS: F & SPACER COUPLING |

**NOTE:**

**1. In 2 Nos, 1 Nos in operation & 1 No standby**

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# BUILDING MANAGEMENT & ENERGY MANAGEMENT CONTROL SYSTEM WORKS

# BUILDING MANAGEMENT & ENERGY MANAGEMENT CONTROL SYSTEM

## PART 1 - GENERAL

### 1.1 SECTION INCLUDES

A. General Requirements

B. Description of Work

C. Quality Assurance

D. System Architecture

E. Distributed Processing Units/Quantity and Location

F. Demolition and Reuse of Existing Materials and Equipment

G. Sequence of Work

### 1.2 RELATED DOCUMENTS

A. Mechanical Materials and Methods‖

B. ¯Sequence of Operation‖ - Project Mechanical HVAC Drawings

C. ¯Energy Management Control System (EMCS) Basic Materials, Interface Devices, and Sensors,‖ including:

1. EMCS Operator Interfaces

2. EMCS Field Panels

3. EMCS Communication Devices

4. EMCS Software and Programming

5. EMCS Commissioning

### 1.3 DESCRIPTION OF WORK

A. The distributed digital control (DDC) and Energy Management Control System (EMCS) defined in this specification shall seamlessly interface with the Bank Building Management/Controls System and shall utilize the BACnet communication requirements as defined by ASHRAE/ANSI 135-2001, or Echelon LonTalk Protocol as defined by EIA/CEA-709.1-A-1999 for all communication between building automation systems and the EBI operator workstation either directly or through a BACnet gateway(s). Towards this end, contractor shall provide a router/gateway(s) as necessary to facilitate all specified objects and services and have them configured/mapped as applicable.

B. Contractor shall furnish and install a direct digital control and Energy Management Control System (EMCS). The new EMCS shall utilize electrical/electronic sensing, microprocessor- based digital control, and electronic and/or electrical/electronic actuation of dampers and valves to perform control sequences and functions specified. The EMCS for this project will generally consist of monitoring and control of systems listed below. Reference also, control drawings, sequences of operation, and points lists.

C. The systems to be controlled under work of this Section basically comprise of variable volume and constant volume air handling units, hydronic system consisting of hot water boilers, pumps, chilled water and heating hot water piping, The HVAC systems being controlled are:

1. Variable volume air handling units with terminal reheat.
2. Constant volume system with terminal reheat coil, and zone shutoff dampers.
3. General Exhaust system.
4. Building heating boilers, pumps, and water loop connections.

D. This Section defines the manner and method by which these controls function.

## 1.4 PROCUREMENT

A. The EMCS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system of the following manufacturer. No other vendor products will be accepted as substitutions.

## 1.5 QUALITY ASSURANCE

A. **Product Line Demonstrated History**: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 5 years since date of final completion in at least 10 installations of comparative size and complexity. Submittals shall document this requirement with references.

B. **Installer's Qualifications**: Firms specializing and experienced in control systeminstallations for not less than 5 years. Firms with experience in DDC installation projects with point counts equal to this project and systems of the same character as this project. If installer is a Value Added Reseller (VAR) of a manufacturer‘s product, installer must demonstrate at least 5 years prior experience with that manufacturer‘s products. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references.

C. **Installer's Experience with Proposed Product Line**: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than five year from date of final completion on at least 10 projects of similar size and complexity. Submittals shall document this experience with references.

D. **Installer‘s Field Coordinator and Sequence Programmer Qualifications**: Individual(s) shall specialize in and be experienced with control system installation for not less than 5 years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than 2 projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. The proposed individuals must show proofof the following training:

1. **Product Line Training**: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on

that product line for installation and configuration

2. **Programming Training**: Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the Manufacturer.

E. **Installer's Service Qualifications**: The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum 5 year history of servicing installations of similar size and complexity. Installer must also document at least a 5 year history of servicing the proposed product line.

F. Installer's Response Time and Proximity:

1. Installer must maintain a fully capable service facility within a 45 mile radius of the project site. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.

2. Emergency response times are listed below in this Section. Installer must demonstratethe ability to meet the response times.

## 1.6 DEFINITIONS

A. **Advanced Application Controller (AAC)**: A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.

B. **Application Protocol Data Unit (APDU)**: A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).

C. **Application Specific Controller (ASC)**: A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications.

D. **BACnet/BACnet Standard**: BACnet communication requirements as defined by ASHRAE/ANSI 135-2001.

E. **BACnet Interoperability Building Blocks (BIBB)**: A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.

F. **Binding**: In the general sense, binding refers to the associations or mappings of the sources network variable and their intended or required destinations.

G. **Building Controller (BC):** A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.

H. **Change of Value (COV)**: An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-2001).

I. **Client**: A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.

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J. **Continuous Monitoring**: A sampling and recording of a variable based on time or changeof state (e.g. trending an analog value, monitoring a binary change of state).

K. **Controller or Control Unit (CU)**: Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.

L. **Control Systems Server (CSS)**: This shall be a computer (or computers) that maintains the systems configuration and programming database. This may double as an operator workstation.

M. **Direct Digital Control (DDC)**: Microprocessor-based control including Analog/Digital conversion and program logic

N. **Energy Management Control System (EMCS)**: The entire integrated management and control system

O. **Enterprise Buildings Integrator (EBI)**: An Enterprise-level, Intranet-based network connecting multiple buildings on Hospital's site with a central data warehouse and server, accessible via the host computer.

P. **Functional Profile**: A collection of variables required to define a the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.

Q. **Gateway (GTWY)**: A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-2001).

R. **Hand Held Device (HHD)**: Manufacturer's microprocessor based device for direct connection to a Controller.

S. **Host-Based Controller**: A term applicable only to Lon-based controllers where the on- board Neuron chip is used solely as the Communications Interface and a processor independent from the Neuron chip to is used to execute Application control and I/Oprocesses.

T. **IT LAN:** Reference to the facility's Information Technology network, used for normal business related e-mail and Internet communication.

U. **LAN Interface Device (LANID)**: Device or function used to facilitate communication and sharing of data throughout the EMCS

V. **Local Area Network (LAN)**: General term for a network segment within the architecture. Various types and functions of LANs are defined herein.

W. **Local Supervisory LAN:** Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs and CSSs and the LAN to which the EBI will be interfaced. See System Architecture below. THIS CAN BE THE PRIMARY LAN.

X. **Master-Slave/Token Passing (MS/TP)**: Data link protocol as defined by the BACnet standard. (ASHRAE/ANSI 135-2001).

Y. **Open Database Connectivity (ODBC)**: An open standard application-programming interface (API) for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.

Z. **Operator Interface (OI)**: A device used by the operator to manage the EMCS including OWSs, POTs, and HHDs.

AA. **Operator Workstation (OWS)**: The user's interface with the EMCS. As the EMCS network devices are stand-alone, the OWS is not required for communications to occur.

BB. **Point-to-Point (PTP)**: Serial communication as defined in the BACnet standard.

CC. **Portable Operators Terminal (POT)**: Laptop PC used both for direct connection to a controller and for remote dial up connection.

DD. **Protocol Implementation Conformance Statement (PICS)**: A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device (ASHRAE/ANSI 135-2001).

EE. **Primary Controlling LAN**: High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.

FF. **Router**: A device that connects two or more networks at the network layer.

GG. **Secondary Controlling LAN**: LAN connecting AACs and ASCs, generally lower speed and less reliable than the Primary Controlling LAN. Refer to System Architecture below.

HH. **Server**: A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.

II. **SQL**: Standardized Query Language, a standardized means for requesting informationfrom a database.

JJ. **Standard Network Variable Type (SNVT)**: A form of APDU specifically used to bind LonWorks control data across a LonWorks network.

KK. **XIF File**: A file indicating the interface specifications for LonMark devices.

LL. **XML (Extensible Markup Language)**: A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.

## 1.7 FUNCTIONAL INTENT

A. The Sequences of Operation and detailed requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement. Contractor may submit products that utilize alternate means, methods, and configurations that meet the functional intent. However these will only be allowed with prior approval.

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## 2. SCOPE OF WORK

a. The Building Management System (BMS) Contractor/manufacturer shall furnish and install a fully integrated Building Management System, incorporating direct digital control (DDC) for energy management equipment monitoring and control and subsystem system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in this specification as herein specified complete temperature humidity & pressurization systemas specified herein.

All components of the system – workstations, servers, application controllers, unitary controllers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2004, or EIA standard 709.1, the LonTalk™ protocol, or Modbus protocol.

The installation of the control system shall be performed under the direct supervision of the Consultant & controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.

b. All materials and equipment used shall be standard components, regularly manufactured for this and / or other systems and not custom designed specially for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years.

c. BMS manufacturer shall be responsible for all BMS and logic control wiring for a complete and operable system. All wiring shall be done in accordance with all local andnational codes.

d. Provide controls for the following:

*ENGINEERING SYSTEM*

1) 4- Nos of Gen-Set Status Power Monitoring + Fuel Management System.
2) 2- Nos of HT Panel Power Monitoring & Energy Management(Volt, Amps, Hz,Kw-Hr & Tariff) System .
3) 1- No Sync.Panel Power Monitoring.
4) 1- No Power Factor Panel Power Monitoring.
5) 1- No Phase Sequence Panel Power Monitoring.
6) 1- No Automatic Diesel Fueling System + Fuel Management System.
7) 1- No Automatic Water Filling System + 2 Nos of Under Ground/1 No of Overhead Tank Management System..
8) 6- Nos Elevators

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HVAC SYSTEM

1) 10- Nos of Air-Handling Units Controls & Monitoring.
2) 2- Nos of Fresh Air-Handling Units Controls & Monitoring.
3) 2- Nos of Primary Chilled Water Pumps Start/Stop & Monitoring.
4) 2- Nos of Secondary Chilled Water Pumps Start/Stop, Controls & Monitoring.
5) 2- Nos of Condenser Water Pumps Start/Stop & Monitoring.
6) 2- Nos of Hot Water Pumps Start/Stop & Monitoring.
7) 1- Nos of Cooling Tower Start/Stop, Controls & Monitoring.
8) 1- Nos of Hot Water Boiler Monitoring & Fuel Management System.
9) 1- Nos of Electrical Operated Screw Chiller Start/Stop & Monitoring.
10) 6- Nos of Stair Case Pressurization Start/Stop, Controls & Monitoring.
11) 1- No of Smoke Evacuation Start/Stop, Controls & Monitoring.
12) 6- Nos of Temp & Humidity Monitoring of UPS & Cabinet.
13) 2- Nos of Temp Monitoring of each floor of Main Building.

FIRE PROTECTION SYSTEM

1) 1- Set of Fire Pump System Status Start/Stop & Monitoring.
2) 1- No Automatic Water Filling System of Fire Tank + Management System..
3) 5- Nos of Fire Protection System, Line Pressure Monitoring.
4) ZCV,s Supervisory Switch/Flow Switch Monitoring.
5) Automatic Control Valve Supervisory Switch/Flow Switch Monitoring.
6) Fire Alarm Panel Monitoring.
7) 4- Nos of Release of Clean Agent Monitoring.

SAFETY SYSTEM

1) 1- Set of UVSS (Under Vehicle Surveillance System) Recording & Monitoring.
2) 1- Set of Driver Surveillance System Recording & Monitoring.
3) 2- Nos of Walk Through Gates Recording & Monitoring.

e. Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other necessary equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete system.

Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.

f. The BAS contractor shall review and study all HVAC/Mechanical system drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

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g. All interlocking wiring, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BAS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.

h. Testing & commissioning of the system shall be performed by manufacturers authorized/ trained engineer in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.

i. All work performed under this section of the specifications will comply with all governing codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor, with guidance from the engineer, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

## 3. Work by Others

i. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.

ii. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.

iii. The BAS Contractor shall provide field supervision to the designated contractor for theinstallation of the following:

1. Automatic control dampers
2. Blank-off plates for dampers that are smaller than duct size.
3. Sheet metal baffles plates to eliminate stratification.
4. The Electrical Contractor shall provide:
   a. All power wiring to motors, heat trace, junction boxes for power to BASpanels.
   b. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BAS Contractor to hardwire to fan shut down.
   c. Auxiliary contact (pulse initiator) on the electric meter for central monitoring ofkWh and KW. Electrical Contractor shall provide the pulse rate for remote readout to the BAS. BAS contractor to coordinate this with the electricalcontractor.

## 4. RELATED WORKS

1. Supply, Installation, Testing & Commissioning of Building Management System (BMS) complete in all respects including controls sensors, DDC controller, Control wiring, flexible G.I. (plastic coated) pipe, termination, Low voltage power supply, control transformer, magnetic contractors with start/off AUTO/Manual switches etc as per specifications, drawings & as per instruction of Consultant.

2 The Building Management System (BMS) control equipment for systems and components, including BACnet /Open Protocol Control Components. Depending on the scope of the project.

## 5. CODES AND STANDARD COMPLIANCE

d. The following codes and standard intended to apply as applicable as not all will apply to all installations

e. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

i. ASHRAE 135-2001: BACnet - A Data Communication Protocol for Building Automation and Control Networks. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2001

f. Electronics Industries Alliance

i. EIA-709.1-A-99: Control Network Protocol Specification

ii. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification

iii. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

iv. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes

v. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.

vi. EIA-472: General and Sectional Specifications for Fiber Optic Cable

vii. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications

viii. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications

ix. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber OpticCable Plant and all Sectional Specifications

g. Underwriters Laboratories

i. UL 916: Energy Management Systems.

h. NEMA Compliance

i. NEMA 250: Enclosure for Electrical Equipment

ii. NEMA ICS 1: General Standards for Industrial Controls.

i. NFPA Compliance

i. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

ii. NFPA 70 National Electrical Code (NEC)

iii. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.

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j. Institute of Electrical and Electronics Engineers (IEEE)

i. IEEE 142: Recommended Practice for Grounding of Industrial and CommercialPower Systems

ii. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN

iii. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN

h. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.

i. Provide BAS components and ancillary equipment, which are UL-864 UULK Listed andlabeled.

j. All wiring shall conform to the National Electrical Code.

k. All smoke dampers shall be rated in accordance with UL 555S.

l. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices andlow power communication equipment operating in commercial environments.

m. Comply with FCC, Part 68 rules for telephone modems and data sets

## 6. QUALITY ASSURANCE

a. The BMS system shall be designed and installed, commissioning and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-placesupport facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

b. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control system and shall be manufacturer's latest standard design that complies with the specification requirements

c. The manufacturer of the Building Management System shall provide documentation supporting compliance with ISO 9002 (Model for Quality Assurance in Production, Installation and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a quality system and Framework that will assure consistency in the products delivered for this project.

d. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels and extend new field panels on a previously installed network.

## 7. WARRANTY

a. Contractor shall warrant all products and labor for a period of 5 years after Final Acceptance.

b. The Bank reserves the right to make changes to the EMCS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the bank, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the EMCS. Any disagreement between the Hospital and the Contractor on such matters shall be subject to resolution through the contract ‗Disputes' clause.

c. At no cost to the Hospital, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Maintenance services shall be provided for all devices and hardware, Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.

2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the bank to the Contractor.

   a. Response by telephone to any request for service shall be provided within two (2) hours of the Bank,s initial telephone request for service.

   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Bank,s site within four (4) hours of the Hospital's initial telephone request for such services, as specified.

3. Normal Service: Any malfunction, failure, or defect in any hardware componentor failure of any control programming that would not result in property damageor loss of comfort control shall be corrected and repaired following telephonic notification by the Bank to the Contractor.

   a. Response by telephone to any request for service shall be provided withinfour (4) working hours (contractor specified 40 hr per week normal working period) of the Bank,s initial telephone request for service.

   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Bank's site within two (2) working days of the Bank's initial telephone request for such services, as specified.

d. The adjustment required testing and repair of the system include all computer equipment, transmission equipment and all sensors and control devices.

e. The online support services shall allow the local BMS subcontractor to dial out over telephone lines to monitor and control the facility‘s Building Management System. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. The coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

If the problem cannot be resolved on-line by the local office, the national office of the Building Management System manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services, the BMS manufacturer shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

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PART-2 TECHNICAL

## 8. SUBMITTALS

**Submittal at Bid time:** Submit complete control system architecture as defined below and descriptions of the controls system proposed as included in the bid fee. This submittal must beincluded as part of the fee bid package. Any exception to this specification, potential additionalcost and any alternative options must be clearly indicated in this proposal.

a. **Drawings and Diagrams**: Shop drawings shall be provided on electronic media as an AutoCAD 2009 or later version drawing file and Adobe Portable Document Format file. All _x reference' and font files must be provided with AutoCAD files.

Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.

Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.

Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three ring binder with an index and tabs. Diagrams shall be on 11‖ by 17‖ foldouts. If color has been used to differentiate information, the printed copies shall be in color.

Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor, prior to submitting, shall check all documents for accuracy.

Submit 3 complete sets of documentation in the following phased delivery schedule:

1. Valve and damper schedules
2. Equipment data cut sheets
3. System schematics, including:
4. Sequence of operations
5. Point names
6. Point addresses
7. Interface wiring diagrams
8. Panel layouts
9. System riser diagrams
10. Auto-CAD compatible as-built drawings

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Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include verbal description of sequence of operation.

All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.

With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number) and Mechanical and Electrical Drawings for Points List and additional requirements.

Label each control device with setting or adjustable range of control. Label each input and output with the appropriate range.

Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc.as applicable.

With each schematic, provide valve and actuator information including size, Cv, designflow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.

Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladderlogic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring, which are, factory-installed and portions to be field-installed.

b. **Electronic Submittals**: While all requirements for hard copy submittal apply, control submittals and O&M information shall also be provided in electronic format as follows.

**Drawings and Diagrams**: Shop drawings shall be provided on electronic media as an AutoCAD 2009 or later version drawing file and Adobe Portable Document Format file. All _x reference' and font files must be provided with AutoCAD files.

**Other Submittals**: All other submittals shall be provided in Adobe Portable Document Format.

c. **Qualifications**: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate item above.

d. **Product Data**: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.

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**e. Open Protocol Information**

1. LonWorks Systems (Any system using LonWorks shall include the following):

a. Binding table indicating all Network Variables used in the project, Neuron ID and domain, subnet and channel address, and associated bound variables. Clearly indicate which parameters of a functional profile are bound and can be overridden.

b. A point binding diagram shall be provided with each control schematic depicting all bound network variables along with the associated functional profiles.

c. LonMark functional profile certifications.

d. For Host-Based Controllers: Controller programming and configuration tool and or plug in required for all controllers with a minimum of 3 licenses as applicable.

e. For non-host Controllers: LonTalk Neuron C source code and/or Neuron C application programming interface tool (3 licenses) and associated files required forall controllers.

f. Backup of systems configuration database on CD. This shall be provided at substantial completion and at the end of the warranty period.

g. Documentation of all explicit messaging.

h. XIF files for all LonMark components.

2. BACnet Systems (Any system using BACnet shall include the following):

i. BACnet object description, object ID, and device ID, for each I/O point.

j. Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.

k. Submit PICS indicating the BACnet functionality and configuration of each controller.

f. **EBI Interface Information**: Provide a Points List in both hard copy and in electronic format (ODBC compliant). The Points List shall contain a listing of building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID or node number, object ID (objecttype, instance number)

g. **Framed Control Drawings**: Laminated control drawings including system control schematics, sequences of operation and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

**h. Control Logic Documentation:**

1. Submit control logic program listings (for graphical programming) and logic flow charts illustrating (for line type programs) to document the control software of allcontrol units.

2. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.
3. Include written description of each control sequence.
4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.
5. Sheets shall be consecutively numbered.
6. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
7. Include Table of Contents listing sheet titles and sheet numbers
8. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials.

i. **Operation and Maintenance Material:**

a. Upon project completion, submit operation and maintenance manuals, consisting of the following:

Index sheet, listing contents in alphabetical order
Manufacturer‘s equipment parts list of all functional components of the system,Auto-
CAD disk of system schematics, including wiring diagrams
Description of sequence of operations As-
Built interconnection wiring diagrams
Operator‘s manual
Trunk cable schematic showing remote electronic panel locations and all trunk data List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
Conduit routing diagrams

b. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as ¯As-Built‖.

1. System architecture drawing.
2. Layout drawing for each control panel
3. Wiring diagram for individual components
4. System flow diagram for each controlled system
5. Instrumentation list for each controlled system
6. Sequence of control
7. Binding map
8. Operation and Maintenance Manuals

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c. Information common to the entire system shall be provided. This shall include but not be limited to the following.

1. Product manuals for the key software tasks.
2. Operating the system.
3. Administrating the system.
4. Engineering the operator workstation.
5. Application programming.
6. Engineering the network.
7. Setting up the web server.
8. Report creation.
9. Graphics creation.
10. All other engineering tasks.
11. System Architecture Diagram.
12. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
13. Define the task.
14. Recommend a frequency for the task.
15. Reference the product manual that includes instructions on executing the task.
16. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
17. Licenses, guarantees, and warranty documents for equipment and systems.
18. Submit one copy for each building, plus two extra copies.

d. Software shall be provided:

1. Submit a copy of all software installed on the servers and workstations.
2. Submit all licensing information for all software installed on the servers and workstations.
3. Submit a copy of all software used to execute the project even if the softwarewas not installed on the servers and workstations.
4. Submit all licensing information for all of the software used to execute theproject.
5. All software revisions shall be as installed at the time of the system acceptance.
6. Firmware Files
7. Submit a copy of all firmware files that were downloaded to or pre-installed onany devices installed as part of this project.
8. This does not apply to firmware that is permanently burned on a chip at thefactory and can only be replaced by replacing the chip.
9. Submit a copy of all application files that were created during the execution ofthe project.
10. Submit a copy of all graphic page files created during the execution.

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## PART-2 TECHNICAL

## 9. SYSTEM DISCRIPTION

a. In accordance to the scope of work, the system shall also provide a graphical, web- based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing /control functions.

For this project, the system shall consist of the following components but not limited,

2. Administration and Programming Workstation(s): The BAS Contractor shall furnish (qty) Administration and Programming Workstation Computers.

These workstations must be running the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalonecontrollers.

No third party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile.

3. Web-Based Operator Workstations: The BAS Contractor shall furnish licenses for web connection to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control set points and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to supportthe web-based user interface.

4. Standalone Digital Control Units (SDCUs): Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC. BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Advanced Application Controllers (B- AAC).

b. The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, XML and HTTP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computersystem.

c. The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.

## 10. SYSTEM ARCHITECTURE

a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. The Contractor shall include all items not specifically

itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.

b. The system shall be configured as a distributed processing network(s) capable of expansion as specified below.

c. The system architecture shall consist of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-leveled LANs that support BCs, AACs, ASCs, Operator Workstations (OWS), and Remote Communication Devices (RCDs) as applicable. The following indicates a functional description of the EMCS structure.

1. **Enterprise Building Integrator WAN**: Intranet-based network connecting multiple buildings with a central data warehouse and server. Contractor is required to connect to this WAN. Contractor is however required to provide BACnet Objects and services and/or LonMark Objects at the Local Supervisory LAN via BACnet or LonTalk over IP. This EBI contractor shall connect to this Ethernet LAN to manage the exchange of data and alarms with the EBI Server including, but not limited to, trends, alarms, schedules, parameters, variables, and real time data from the local system. If the Local Supervisory LAN does not inherently use BACnet or LonTalk over IP, this Contractor shall provide a gateway(s), routers, hardware, software,etc. necessary to translate and facilitate services from the local protocol to the EBI.

2. **Local Supervisory LAN**: The Local Supervisory LAN shall be an Ethernet-based, 100 Mbps LAN connecting Primary Control LANs and OWSs. The LAN serves as the inter-BC gateway and OWS-to-BC gateway and communications path and as the connection point for the EBI. Contractor shall provide this as a dedicated LAN for the control system. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 5 cable with switches and routers that support 100 Mbps throughput. Power-line carrier communication shall not be acceptable for communications. The higher level layers of this network shall be one of the following at Contractor‘s option:

   a. BACnet Supervisory LAN: BACnet/IP as defined in Addendum A (Annex J) ofthe BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet. Point/Object naming conventions are specified in 15955 - Part III.

   b. onWorks Supervisory LAN: Individual Primary control LonTalk Networks routed over IP using LonTalk to IP routers such as I-Lon, Coactive or equivalent. Point/Object naming conventions are specified in 23 - Part III.

3. **Primary Controller LAN (Primary LAN‘)**: High-speed, peer-to-peer communicating LAN used to connect AACs, ASCs and Building Controllers (BCs) and communicate exclusively control information. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending and other requirements as specified in Division 23. Acceptable technologies include:

   1. Ethernet (IEEE802.3)

   2. ARCNET (IEEE802.4)

   3. LonTalk: The LonTalk standalone EMCS shall be comprised of a network of AACs and ASCs, supporting LonTalk protocol (EIA 709.1) and twisted pair, freetopology (TP/FT-10) transceivers (EIA 709.3). The secondary network shall communicate at 78 kbps. Each secondary TP/FT-10 network may support up to 64 communicating LonTalk devices without segmentation subject to the requirements for response time, trending and bandwidth utilization.

   4. Proprietary: Manufacturer‘s proprietary protocol.

4. **Secondary Controller LAN (Secondary LAN‘)**: Network used to connect AACs, or ASCs.

These can be Master Slave/ Token Passing or polling, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements.

d. **Dynamic Data Access**: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.

e. **Remote Data Access**: The system shall support the following methods of remoteaccess to the building data.

1. Dial-in via minimum of a 56k modem. Dial-in connection shall allow access to all control system facilities and graphics with appropriate password. The Bankshall provide and pay for the digital grade voice line to support this remote connection.
2. DSL. All workstations shall be equipped with standard 100 megabit Ethernet cards; the Hospital at its option may elect to use DSL or other broadband service to access the system.

f. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with shop drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:

1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at the EBI workstation.
2. 10 seconds between a Level 2 alarm occurrence and enunciation at the EBI workstation.
3. 20 seconds between and a Level 3-5 alarm occurrence and enunciation at the EBI workstation.
4. 10 seconds between an operator command via the EBI workstation to change a set point and the subsequent change in the controller.
5. 5 seconds between an operator command via the EBI workstation to start/stop a device and the subsequent command to be received at the controller.
6. 10 seconds between a change of value or state of an input and it being updated on the EBI workstation.
7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.

5. **Operator Workstation (OWS)**: This shall be a computer (or computers) that maintain the systems configuration and programming database. It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non- control system based programs, and shall be located at the building or buildings being controlled. It shall allow secure multiple-access to the control information. Refer to Section ¯EMCS Operator Interfaces‖ for its requirements.

Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. Interfaces.‖

The BCs, AACs, ASCs, shall monitor, control, and provide the field interface for points specified. Each BC, AAC, or ASC shall be capable of performing specified energy management functions, and DDC functions, independent ofother BCs, AACs, or ASCs and operator interface devices.

6. **Systems Configuration Database**: The system architecture shall support maintaining the systems configuration database on a server or workstation on the Local Supervisory LAN. User tools provided to the Bank shall allow configuring, updating, maintaining, etc. current configurations and settings whether they are initiated at the server or the end device.

   Database Schematic shall be published and provided to the Bank to facilitate easy access to the data.

   Database shall be ODBC compliant or a data access driver shall be provided toact as an ODBC or OLE DB data provider.

   For LonWorks systems the SCD and associated network services shall be LonWorks Network Services (LNS) (latest version) compliant. The Network Management Application shall be LonMaker™ for Windows (latest released version) service tool (including hardware, software and any peripheral devices required) and is to be used for commissioning and management of the LonTalk control architecture. The network management service tool shall remain on the project as the property of the bank. A copy of the LonTalk network database shall be archived on the service tool, documenting system bindings and node addressing. In addition all system variables shall have a plain English language description for each variable. This service tool shall be used for all system maintenance and expansion, so that the network database backup remains current

   Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.

   All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.

B. Anytime any controller‘s database or program is changed in the field, the controller shall be capable of automatically uploading the new data to the CSS.

## 11. NETWORKING COMMUNICAITONS

a. The design of the BMS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a campus wide Ethernet network BMS on TCP/IP protocol, a high performance peer-to-pee building level network and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs

b. Peer-to-Peer Building Level

1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any

and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.

2. The network shall support a minimum 25 DDC controllers and PC workstations.
3. Each PC workstation shall support a minimum of 4 peer to peer networks hardwired or dial up.
4. The system shall support integration of third party systems (fire alarm, security, lighting, PCL, chiller, boiler) via. Panel mounted open protocol processor. This processor shall exchange data between the two systems for inter process control. All exchange points shall have full system functionality as specified herein for hardwired points.

## 12. DDC CONTROLLER FLOOR LEVEL NETWORK:

1. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC controllers for transmission of global data.

2. Telecommunication capability:

   a. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator stations and/or remote terminals via telephone lines, as indicated in the sequence of operations.

   b. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events. The auto-dial program shall include provisions for handling busy signals, ¯no answers‖ and incomplete data transfers.

   c. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all data based generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote DDC controllers. The fact that communications are taking place with remote DDC Controllers over telephone lines shall be completely transparent to an operator.

## 13. DDC CONTROLLER

a. DDC Controllers shall be a 64 bit stand-alone, multi-tasking and multi-user, real time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of two (3) Floor Level LAN Device Network.

b. Each DDC Controller shall have sufficient memory to support its own operating system and data bases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages of each level alarmfor each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom Processes

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7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

c. Each DDC Controller shall support firmware upgrades without the need to replace hardware.

d. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

e. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers for terminals.

f. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control typepoints and gradual switches for analog control type points.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure or externally mounted with each switch keyed to prevent unauthorized overrides.

2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

Note: Provide I/O schedule for points needing manual override)

a. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

b. Each DDC Controller shall continuously perform self- diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

c. Isolation shall be provided at all peer-to-pee network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEEStandards 587-1980.

d. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non- volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real time clock and all volatile memory for a minimum of 72 hours.

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1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without Manual intervention.
2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, viatelephone line dial-in or from a network workstation PC.

e. Provide a separate DDC Controller for each Supply Air Fan with its related exhaust fan as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller.

## 14. DDC CONTROLLER RESIDENT SOFTWARE FEATURES

a. General

1. The software programs specified in this section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.

b. Control Software Description:

1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

   a. Two-position control
   b. Proportional control
   c. Proportional plus integral control
   d. Proportional, integral, plus derivative control
   e. Automatic tuning of control loops

c. DDC Controllers shall have the ability to perform any or all the following energymanagement routines:

1. Time-of-day scheduling
2. Calendar Based scheduling
3. Holiday scheduling
4. Temporary schedule overrides
5. Start-Stop Time Optimization
6. Automatic Daylight Savings Time Switchover
7. Night setback control
8. Enthalpy switchover (economizer)
9. Peak demand limiting
10. Temperature compensated duty cycling

d. DDC Controllers shall be able to execute custom, job specific processes defined by theuser, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controller on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network. Data Based shall support 30 character, English language point names, structured for searching and logs.
2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
3. DDC Controller shall provide a HELP function key.
4. DDC Controller shall be capable of comment lines for sequence of operation explanation.

e. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controller ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm message to more fully describe the alarm condition or direct operator response.
5. In dial-up applications, operator selected alarms shall initiate a call to a remote operatedevice.

f. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.

1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored each DDC Controllers point groups. Two methods of collection shall be allowed; either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of I minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM based buffer for trend data and shall be capable of storing a minimum of data samples.All trend data shall be available for use in 3rd party personal computer applications 9i.e Microsoft Excel, Lotus 123).
2. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator initiated automatic and manual loop tuning algorithms shall be provided for operator selected PID control loops as identified in the point I/O summary.

3. Loop tuning shall be capable of being initiated either locally at the DDC Controller, froma network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.

g. DDC Controllers shall be capable of automatically accumulating and storing run-time hour or digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

h. The peer to peer network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate-processing device. Thepeer to peer network shall also allow any DDC Controller to access, edit modify, add, delete, backup and restore all system point data base and all programs.

a. The peer to peer network shall allow the DDC Controllers to assign a minimum of 50 password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

## 15. CENTRAL SYSTEM CONTROLLERS:

1. Provide for control of all equipment including but not limited to the following:

   a. Air-Handling Units
   b. Primary & Secondary Chilled Water/Condenser Water Pumps/Hot water Pumps
   c. Screw Chiller
   d. Hot water heater
   e. Energy Analyzer
   f. Ventilation Fans
   g. Exhaust Fans
   h. Pressure monitoring system

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either the controller's key- accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order toinform the system that automatic control has been overridden.

3. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.

4. All programs shall be field customized to meet the users exact control strategy requirements. Central System controllers utilizing pre-packaged or caned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control

strategy requirements.

5. Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide an DDC Controller to meet the specified functionality.

## 16. PESONAL COMPUTER OPERATOR WORKSTATION HARDWARE

a. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and data bases management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

1. Workstation shall consist of an SVGA 17‖ color monitor, personal computer with minimum 256 DIM, 20.0 GB hard drive and controller 3-1/2‖ diskette drive, 52 X CD Drive, mouse and 101-key enhanced keyboard. Personal computer shall be an IBM compatible PC, DELL Branded and shall include a minimum Intel Pentium 4 processor.

2. Display provided for system operation shall have a diagonal screen measurement of no less than ----------and a minimum display resolution of no less than 640x480 pixels. Separate controls shall be provided for color, contrasts and brightness. The screenshall be non-reflective.

b. Provide an Epson FX-870 or equivalent printer at each workstation location for recording alarms, operator transactions and systems reports, meeting the following minimum requirements:

## 17. WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum thefollowing functionality;

a. Real-time graphical viewing and control of environment
b. Scheduling an override of building operations
c. Collection and analysis of historical data and dynamic data (trend plot)
d. Definition and construction of dynamic color graphic displays
e. Editing, programming, storage and downloading of controller data base.
f. Alarm reporting, routing, messaging and acknowledgement

2 Provide a graphical user interface, which shall minimize the use of keyboard through the use of a mouse or similar pointing device and ―point and click‖ approach to menu selection. There shall be a minimum of 8 pre-defined function keys to allow quick access to frequently used applications.

3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run within the on windows 98. These window applications shall run simultaneously with the BMS software. The mouse of Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Work, Excel and other Windows Based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.

a. Provide functionality such that any of the following may be performed simultaneously on-line and in any combination, via user sized windows:

1. Dynamic color graphics and graphic control
2. Alarm management, routing to designated locations and customized messages.
3. Week at a Glance Time of day scheduling
4. Trend data definition and presentation
5. Graphic definition and construction
6. Program and point data base editing on-line

b. If the software is unable to display several different types of displays at the same time, the BMS contractor shall provide at least two operator workstations.

c. Report and alarm printing shall be accomplished via windows program manager,allowing use of network printers.

4. Multiple level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, base upon an assigned password. A minimum of six levels of access and 50 passwords shall be supported.

5. Operator Activity Tracking. An audit trail report to track system changes, accounting foroperator initiated actions, changes made by a particular person or changes made to a specific piece of equipment, designated time frame, shall be printable and archived for future use. The operator activity tracking shall be in a tamper proof buffer file.

6. Reports shall be generated on demand or via pre-defined schedule and directed to CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all or selected points in the network
b. List of all points currently in alarm
c. List of all points currently in override status
d. List of all disabled points
e. List of all points currently locked out
f. List of user accounts and access levels
g. List all weekly schedules
h. List of holiday programming
i. List of limits and dead bands
j. Excel reports
k. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
l. List of programs

## 18. SCHEDULING AND OVERRIDE

Provide a graphical spread sheet type format for simplification of time of day scheduling and overrides of building operations. Schedules reside in both the PC workstation and DDC Controller to ensure time equipment scheduling when PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spread sheet graphic types as a minimum.

a. Weekly schedules
b. Zone schedules

c. Monthly calendars

## 19. COLLECTION AND ANALYSIS OF HISTORICAL DATA

a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

b. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

c. Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of size points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take ¯snapshots‖ of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed

1. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or Bitmap drawings for use in the system.

3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

d. Analog bars in 3 sizes shall be available for monitor and control of analog values: high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to ¯click and drag‖ the pointer to change the set point.

e. Provide the use the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

f. Equipment State can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or set point.

Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

g. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

h. Off the shelf graphic software, graphics Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.

i. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.

j. System Configuration & Definition

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1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

2. Provide automatic backup and restore of all DDC Controller data bases on the workstation hard disk. In addition all data base changes shall be performed while the workstation is online without disrupting other system operations. Changes shall be automatically recorded and down loaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

3. System configuration programming, editing, graphics generation shall be performed on-line. If programming and system back-up must t be done with the PC workstation off-line, the BMS contractor shall provide at least 2 operator workstations.

k. Alarm Management

1. Alarm Routing shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity or point type

2. Alarm notification shall be provided via two alarms icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BMS alarm display screen shall be displayed when the user clicks on the alarm icon.

3. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message.

4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

## 20. FIELD DEVICES

A. All devices and equipment shall be approved for installation in the city of Karachi

B. Temperature Sensors with accuracy of ± 2 deg F @ 72 deg F)

1. Digital room sensors shall have LCD display day/night override button and set point slide adjustment override options. The set point slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
2. Built-in port allows connection of Portable operator terminal to query and modify operating parameters on room level sensor.

3. Room sensors shall have sensing accuracy of ± 1 deg F.

C. Humidity Sensors with accuracy of ± 2% RH @ 72 deg F, range of 20% to 95% RH,including hysteresis, linearity and repeatability

D. Pressure Sensors
E. Dampers Actuator with motors sized for specific application
F. Automatic Modulating Control Valves, sized for specific application
G. Differential Pressure Switch
H. Differential Pressure Transmitters for Room Pressure
I. Pressure Electric Switch (PE)

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J. Instrument Air Supply

## 21. SENSING AND CONTROL OUTPUTS REQUIREMENT

All sensing input shall be provided via industry standard signals. Temperature, Humidity, Differential Pressure Signals etc and all other signal inputs shall be one ofthe type as mentioned,

0-20 mA
4-20 mA
0-5 VDC
0-12 VDC
Resistance Signals
On/Off Dry contact closure
All signal inputs shall be compatible with the controllers used, and with the requirements for readout of variables as specified.

### Control Output

### (a) On/Off outputs

Control panel shall internally provide test points for the circuit driving the equipment contactor, for the purpose of troubleshooting whether the 220 VAC circuit to the contactor is active. All such relays or digital output module shall provide a pilot light or LED display of this same status.

### (b) Modulating Output

Modulating outputs shall be industry standard 0-5 VDC, 0-12 VDC, Milli amp outputs of0-20 mA. Drive open/Drive closed type modulating outputs are acceptable provided that they also comply with the below requirements,
All modulating outputs shall provide within the control panel, a metric gauge, or display indication of the commanded position signal to the actuating device. This meter, gauge, or display must provide either a 0-100 percent position indication, or readout directly inthe engineering units of the signal being used Drive open/Drive closed type controllers shall include sufficient components and control algorithms to comply with the requirements.

## 22. FIRE STATS

The Air-Handling Unit discharge air sensor shall act as Fire-Stat, It will monitor the discharge air temperature, and upon its higher then user specified limits the respective AHU shall be brought to fail safe condition.

## 23. CONTROLLED DEVICES

The Valves for the air handling units would be three way/ two way as shown on control schematics, proportional type. The control valves for the FCUs would be 3 way two position type. All valves shall be capable of handling the system design temperature and pressure. The valve will incorporate a factory assembled actuator. All valves 2" and smaller will have threaded, larger size valves will have standard flange connection.

All the valves shall close bubble tight against the operating head of the system. All valves shall be sized for the maximum pressure drop of 40 KPa unless specified otherwise hereinafter. All straight through water valves shall have equal percentage characteristics plugs. All the valves which are used in sequence with other, and which are 65mm and larger, shall be provided with

positive positioner. valve operator shall be heavy duty type with sufficient close-off pressure, featuring a reversible motor, gear train and necessary relays.

Damper motors shall be designed with a safety factor of 1.5% of torque valve. (Spring return or incremental power as specified). The damper motor shall be suitable formounting directly on the damper linkage.

All the control devices will fail to close position. In case of three way valve, it will close to by-pass mode.

## 24. FLOW SWITCHS

Flow switches shall be packless, vapour-type construction, with all vetted parts madeof brass and designed for mounting in Tees. Devices shall be capable of being mounted in pipe Tee 1" and larger. Paddle shall be provided with removable segments to accommodate required pipe size and flow. Switching shall be single pole, double throw time delay action type, with rating of 5 amps.

## 25. PRESSURE DIFFERENTIAL SWITCHS

Pressure switch to indicate positive flow of air shall be installed at each AHU blower fan, Filter and/or shown on control schematics.

## 26. FUEL MANAGEMENT SYSTEM

Automatic Tank Gauging system which shall be works on Altrasonic / Magnetostrictive principle of level measurement and is used for continuous monitoring of fuel (liquid) inventory in the storage tanks and reporting all the key events through audible, visual alarms and able to interface with BMS system, which shall be include,

- Certified by ATEX for using in Class A/Class B products
- IP 67 (Housing) IP69K (Probe) certified
- Leak Detection, Accuracy: 0.76 Litre/Hour
- User friendly Interface with simple to use BACnet potocol accessible dataFuel level/volume
  Fuel Temperature
  Water Level/Volume Schedule reports daily/weekly/monthlyOne minute inventory
  Alarms reporting via Email/SMS/FaxIn-built Relays for automatic control
  Control diesel theft for Base Telecom stations.
  Alarm on diesel theft or pilferage.
- Water Detection
- Inventory Monitoring
- Delivery Accounting & re-ordering visibility
- Product Quality

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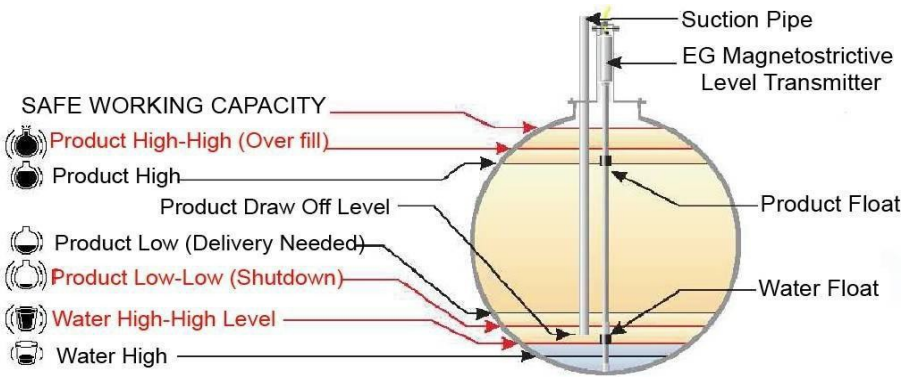
- Environment protection – Leak detection
- Operator's safety
- Losses Accountability
- Compliance Duel Floats – Liquid (Oil) & Water
- Accuracy: +/- 1.0 mm, Resolution:+/- 0.004% F.S.
- Operating Temperature: (-40°C to 200°C) Five Thermistors -Temp Accuracy+/-0.5 ºC Resolution +/- 0.1 ºC
- Rugged & highly reliable – No Maintenance
- **Product Float (level indicator)**

  The product level indicator floats atop the product and registers the overall height ofthe product (including water).
- **Water Float (level indicator)**

  The water level indicator has ballast weights added. Because the product (fuel) is less dense then water, the weight plate forces the water level indicator to sink through the fuelproduct and float on the water.
- **Schematic**




## 27. CONTROL PANEL

Each control panel shall be a fully electronic analog control or digital control system, providing all control functions for the equipment specified to be controlled from the panel. Control functions to be performed by control panels are as described in the specification in the point charts, and other relevant sections of these specifications.

It is the intent of this specification to provide the Employer with the ability to read out temperature and other values, and to adjust specific items from localized control panel. In order to provide this room capability, control panels are specified to be placed in specific locations.

Every control panel shall provide readouts for the temperatures, humidity or other information, specified. Every control panel shall provide adjustments for the set points, parameters, and other adjustment functioned specified.

At the least one control panel will be provided in each Air Handling Room. Controlpanel for ceiling-hung AHU,s shall be installed in vicinity of AHU room.

### Read Out of Items

Items specified for read out may be read through plug-in portable operators terminals which are provided as part of MBCS. At least 2 operator terminals shall be provided. Read out of sensed variables used in control sequences shall be from the same sensors used for controls. As an alternative, provide either a duplicate sensor for the read out, or provide a transducer for each sensed signal and a signal compatible with the controller.

Label shall be part of the digital display of the valves.

### Adjustment

Every control panel shall provide adjustment for the functions specified. In general, adjustments shall be provided for all set point s used by the controllers within each control panel. In addition, adjustments shall be provided for throttling ranges mixed air damper minimum positions, or other items as specified/required adjustment may be made through plug in portable operators device.

## 28. APPLICATION SOFTWARE DOCUMENTATION

Contractor shall provide a blueprint documentation of the software application program for each SDC/SDM. Documentation provided shall include block software flow-chart showing the interconnection between each of the control algorithms and sequences. For system utilizing program listing. A program listing shall be printed onto the same blueprint, along with the program flow chart, and description of the sequence of operation. This blueprint shall be stored and maintained in each SDC/SDM panel. System acceptance shall not be completed until this documentation is provided and located in each panel.

## 29. ENERGY MANAGEMENT CONTROL

The individual SDC's/SDM's shall perform Time of Day, Daily, Weekly, Calendar, Holiday Scheduling, Optimum start/stop, Enthalpy optimization, and all control optimization strategies such as supply air reset, soft start ramp up, for their connected systems of equipment.

## 30. SYSTEM SUPPORT INVENTRY

Provide for the purposes of system support, a complete set of Input / Output circuit board sufficient to replace any failed input output point card in any configuration of control panel.

Also provide

| | |
|---|---|
| Temperature and Humidity sensing | Two of each kind |
| Valve actuators and motors | One of each kind |
| Pressure sensing device | One of each kind |
| Smoke detector, Fire Stat | One of each kind |

These shall be kept on-site, and shall be available for immediately recovering from the loss of point processing capability in any control panel.

## 31. START-UP AND COMMISSIONING

a. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-lien. All testing calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

b. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

## 32. INSTALLATION STANDARDS

GENERAL

1 The intention of this clause is to guide the Contractor as to the quality of installationthat the project requires.

2 The installation shall conform both to manufacture's recommended procedures and allapplicable codes and regulations to the approval of authorities having jurisdiction.

3 All installations to be performed by skilled and certified technicians and trades people.

4 All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor.

5 Equipment shall be installed so as to allow for easy maintenance access. Equipment shall be installed such that it dose not interfere in any way with access to adjacent equipment and personnel traffic in the surrounding space.

6 Equipment shall be installed in locations providing adequate ambient conditions for its specified functioning, allowing for adequate ventilation and with no condensate traps.

7 Equipment with the construction team as a whole, to keep the job reasonably clear of waste material and rubbish at all times during progress of the work.

8 Under the overall direction of the General contractor, co-ordinate activities and co- operate at all times with the other contractors on the project concerning scheduling andinstallation of the work, all phases of commissioning and access to work areas.

## 33. CALIBRATION

1. Set control points immediately after installing controls.
2. Set up and calibrate sensors and control loops during initial start-up of the systems andcheck, re-

calibrate and readjust as necessary during the Commissioning.

3. Submit documentation to the Owner's representative before the systems performance verification indicating the final set points of all controls and confirmation that all control systems have been checked. Documentation may be graphic or tabular.

## 34. EELCTRICAL WORK BY THE CONTROLS CONTRACTOR

1. The following clauses generally indicate the extent of responsibility for electrical wiring included for the controls system.
2. All wiring required for devices supplied under this section of the specification,regardless of the voltage, shall be the responsibility of the Controls Sub Contractor
3. All such work shall be performed in complete accordance with the Electrical Specifications and local codes and may include the following:

a. Provision of control panels, pilot lights, selectors, relays, etc. required for the proper operation of the HVAC System.

b. Conduit and wiring from the starter control circuits to the mechanical system control panels including 110V wiring.

c. Conduit and wiring required for the interlocking of mechanical system motor starters asrequired for the proper operation of the control system.

d. Wiring from pilot devices relays, contractors, or other control interface devices arerequired to complete the control system.

e. Control wiring and interlocking required for refrigeration machines.

f. Wiring from spare 15 amp. Circuit breakers in power panels for line voltage powersources where required by control system. Circuit breakers shall be locking type.

g. Wiring of mechanical component controls.

h. Power wiring and control wiring to stand alone panels and terminal unit controllers.

## 35. ELECTRICAL WORK BY THE MECHANICAL CONTRACTOR

Generally the Electrical Contractor shall be responsible for the electrical connections fromstarters to equipment motors, and the following.

a. All disconnect switches on lock-out station at motor locations where required by localcode.

b. Remote control on Hand/Off/Auto stations where they are not part of a mechanical control system panel.

c. Power wiring to line voltage thermostats controlling force flow units and unit heaters,and wiring to float devices for sump pumps, etc.

d. Space 15 amp. Emergency circuit, one on each floor for controls.

e. Supply and installation of the properly sized overload heaters in the magnetic starters and thermal overload switches.

## 36. CONDUIT, WIRING AND CABLING

1. All work shall be installed to local code requirement.
2. Where there is no alternative to supplying equipment which is not UL or CSA certified, submit such equipment to Inspection Authorities for special inspection and obtain approval before delivery of equipment to site. Such equipment must be individually identified in the Contractor's proposal.
3. Use coded conductors throughout with different colored conductors for each phase and white wire for neutral.
4. Low voltage and communications wiring, size and type of low voltage control signal wiring shall be suitable for the service for which it will be put to use and be the responsibility of this Contractor; minimum wire size # 18 AWG.
5. Identify each wire and cable at every termination point. Identify all conduits with ―neat‖ color bands at no more that 7.5 m intervals and on both sides of walls and floors.
6. 120V circuits shall be, at a minimum, of # 12 AWG RW-90 copper. For runs over 50 m in length, use # 10 AWG-RW90 copper.
7. All wiring in mechanical rooms and service rooms to be in conduit or raceway. Provide 600 mm, B-X flexible connection to input and output devices where required for servicing or to accommodate vibration.
8. All communication wiring between stand alone panels and the Operator Interface shall be installed in conduit. Wiring form SAPs to TUCs does not have to be in conduit except in mechanical and electrical rooms and where direct access is not available.
9. All 120V interlocking wiring and power supplies for panels to be installed in conduit.
10. Provide 120V power supplies to all main DDC panels, separately circuited from allother loads.
11. Low voltage wiring to input and output devices from SAPs and TUCs in not required to be installed in conduit except as noted. Use plenum rated wire in areas used as return air plenums. Provide sleeves where wires pass through walls and floors. Support wires form structure or fixed equipment in ceiling spaces at minimum 2m intervals.

## 37. CONTROL HARDWARE

1. Provide metal enclosures to meet NEMA specs for mounting motor control relays, wiring terminations and components provided which require additional protection.
2. All components shall be positioned to provide easy access for maintenance or replacement.

## 38. INSTALLAITON OF CONTROL DEVICES

1. Sensors provided under this contract shall be installed in accordance with themanufacturer's prescribed procedure.
2. Sensors shall be rigidly mounted and mountings shall be adequate for the environment within which the sensor operates.
3. Supply thermal wells of the appropriate size and type for sensing water temperatures to the mechanical contractor for installation.
4. All wires attached to sensors shall be air sealed in their steel conduits or in the wall tostop air transmitted from other areas affecting sensor readings.
5. Install labels on the inside covers of all room sensors identifying the point name usingpeel and stick labels such as the Brother™ labeling system.

## 39. INSTALLATION OF ACTUATORS

1. Where damper motors operate outdoor relief, exhaust and fresh air dampers,pretension damper drives linkage to ensure tight closure.
2. Do not install damper motors on ductwork of less than 0.76m thick without firstreinforcing it.
3. Where a damper motor is installed on an insulated surface of a duct plenum, mount it on a stand-off bracket so as not to interfere with the continuity of the insulation.
4. Locate damper motors so that they are easily accessible for testing and servicing.
5. Damper motors shall be selected for the torque requirements of the damper. Damper operators that are undersized for the application shall be replaced with larger operators, at no extra cost.
6. Provide one damper motor and linkage for every 2 $m^2$ damper section are or as required to meet the torque requirements of the damper under design air-flow conditions (or minimum of one damper motor per damper section). Do not use two motors linked together on one shaft, or by jackshaft.

## 40. PERFORMANCE TEST ROCEDURES

### OVERVIEW

The successful completion of a SEVEN (7) days acceptance test is a prerequisite to granting performance test. Before the SEVEN (7) days acceptance test may begin, the Air Washer System must be completely operational including the following;

1. Every point shall be checked end to end to ensure accuracy and integrity of systemsand be signed off by the Contractor and the Owner.
2. Generic start up Code shall be written in Operation Control Language (OCL) and successfully control the systems.
3. Time schedules shall be built and in control of time controlled equipment.
4. Graphic displays must be installed and fully operational for each graphic screen pageas per the Air Washer Project Summary.
5. Each control loop measured variable, controlled variable and set point if calculated;shall be placed on a FIFTEEN (15) minute continuous trend for at least TWNTY-FOUR (24) hours to prove stability of loop.
6. Each space sensor shall be placed on a THREE (3) hour trend for One Hundred (100)samples.
7. Runtime tantalizer shall be set on all digital outputs.
8. Load/save of panel programs must be demonstrated.
9. All features of system shall have been exercised.
10. Operator shall have been briefed on operation of system.
11. A trend on one panel shall be set up for a point form every other panel. These points shall also be trended in their own panels for the same intervals. Comparison of the two groups of trends will indicate if any communication problems are occurring during the SEVEN (7) days.
12. All alarms shall be operational.

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13. Calibration of all sensors.

## 41. DURING SEVEN (7) DAYS TEST

1. Power failure for building shall be simulated and system recovery monitored.
2. System must be available for Owner's representative to exercise most features of the system.
3. Demonstration of hardware low limits and damper interlocks will be required.
4. Spot checks of points end-to-end integrity will be carried out. If several problems are identified, a complete reconfirmation of system integrity shall be carried out by the Contractor. When reconfirmation has been completed, the 7 day test will be restarted.
5. Any upset of system operational functionality greater than 2 hours during the 7 day test shall cause the test to be restarted.
6. Printer shall be left on for complete SEVEN (7) day test. All printouts will be kept for review at completion of test. An alarm printer shall be supplied by the Contractor if none is supplied in this contract.
7. Results of all tests shall be documented by the Contractor and submitted to the Engineer for review.

## 42. TRAINING AND DEMONSTRATINS

The complete training program shall be carried out. It may be convenient to schedule this during the 7 days test period.

## 43. DOCUMENTATION

The following documentation must also be in place before completion of SEVEN (7) days test and the granting of Substantial Performance:

1. Panel layout sheets complete with point name, point address and wire identificationnumber. One copy attached to each respective panel door.
2. All points tagged with point name, point address and panel number.
3. System generated data sheets and graphics signed off by both the contractor and the consultant showing successful commissioning of each point.
4. As-Built control drawings showing interface with existing controls.
5. As-Built ladder wiring diagrams showing all hardware interlocks and panel input oroutput number.
6. Complete Operators Manual.
7. Apparatus and maintenance Manual for all sensors, transducers, valves, operators,solid state relays, DDC main panels and zone controllers.

8. Graphic plates of floor plans showing sensors, terminals, devices, zoning and stand alone panel locations.

9. Electrical approval certificate.

10. All of the above information shall be bound and presented in TWO (2) manuals to be left on site.

11. A copy of each graphical screen page shall be signed off and dated by the successful Contractor and the Owner‘s representative. Any changes shall be noted. This signed set shall be left on site as the ¯as installed drawings‖

In addition, a summary prints out generated by the supplied system of each group of point types for each panel shall be printed after commissioning and calibration. Each sheet shall be signed by the Contractor‘s commissioning person and the Owner‘s representatives. The print out will be stored in a binder on site for reference by all parties. If any changes are notedduring spot checks the shall be manually written on the original print out with the date and signature of person noting changes.

## 44. PROJECT ACCEPTANCE

Once the above basic requirements are met and all other features of the system are complete and acceptable, Substantial Performance shall be granted. A deficiency list shall be prepared and holdbacks applied. All deficiencies shall be corrected prior to Total Performance. Warrantyshall start from the date of Substantial Performance of the work.

HVAC SYSTEM

## 45. SEQUENCE OF OPERATION

Before preparing technical submittal for submission to the Engineer for approval, the control manufacturer's qualified representative should hold detailed discussion with the Engineer, along with a qualified representative of the contractor.

After the general consensus on intended functions of control system, the control manufacturer's representative shall prepare a formal Sequence of Operation for submission to Engineer along with technical submittal, to the Engineer through the contractor. Sequence of Operation for both summer and winter modes shall be prepared describing power interlocks, adjustments, fire/smoke detection and smoke controls, SDC failure operation on emergency Set and operating sequences for:

- Air-Handling Units
- Chillers
- Pumps
- Cooling Towers

### 45.1 Sequence of Operation for Normal Air-Handling Units

45.1.1 Automatic temperature control of space, at user defined set point, 2 way chilled water control valve will respond to signal received from return air temperature sensor installed in return air duct/space.

45.1.2 The microprocessor controller shall be standalone with display to monitor and change parameters as required.

45.1.3 The air handling unit fan shall start and stopped from controller manually when H/O/A switch is in manual position, In auto position controller shall act automatically on timescheduling, optimum start/stop, enthalpy optimization and all control optimization strategies.

45.1.4 Motorized damper shall be operated accordingly and open , during fan is in operationof AHU,s otherwise spring return damper close the air circulation path.

45.1.5 Discharge air sensor shall act as fire-stat. It will monitor the discharge air temperature, and upon its higher than the user specified limits the respective AHU shall be brought tofail safe condition.(Alarm shall generated on BMS)

45.1.6 In case of smoke sensor senses the smoke, installed in return air duct, the respective AHU shall be brought to total shut down, in all respect including power shut down. (Critical alarm shall be generated on BMS)

45.1.7 In case of activated the, Fire alarm panel and alarm the zone switch, the respective AHU shall be brought to total shut down, in all respect including power shut down. (Critical alarm shall be generated on BMS)

45.1.8 Differential Pressure Switch, installed for filter status shall monitor the pressure drop across filter, when pressure drop across the filter increases from set point, the alarm indication shall be initiated at DDC Display and on BMS display.

45.1.9 Differential Pressure Switch, installed for fan status shall monitor air flow, in case of air flow failure the fan, an alarm indication shall be indicated at DDC Display and on BMS Display.

DDC Point Summary Chart for each AHU (10 Nos.)

| Description | AI | DI | AO | DO |
|---|---|---|---|---|
| Mixed Air Temperature | 1 | | | |
| Room Relative Humidity | 1 | | | |
| Supply Air Temperature | 1 | | | |
| Smoke Detector | 1 | | | |
| Air Filter P.D | | 1 | | |
| Two Way Motorized Valve | | | 1 | |
| Supply Air Fan P.D | | 1 | | |
| Chilled Water Temp In/Out | 2 | | | |
| Motorized Damper Actuator (0-100 % Adjustment) | | | 3 | |
| Fire Stat | | 1 | | |
| Variable Frequency Drive (0-100 % Adjustment) | | | 1 | |

## 45.2 Sequence of Operation for Cooling Tower

45.2.1 The constant Condenser water temperature shall be maintained at pre-set level by sensing condenser water temperature through variable speed/start-stop of cooling tower fans.

DDC Point Summary Chart for each Cooling Tower (1 No)

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| Description | AI | DI | AO | DO |
|---|---|---|---|---|
| Out Side Air Temperature | 1 | | | |
| Out Side Relative Humidity | 1 | | | |
| Condenser Water Temp In/Out at Header | 2 | | | |
| Variable Frequency Drive (0-100 % Adjustment) for CoolingTower Fan. | | | 2 | |
| CT Fan Failure | | 2 | | |
| CT Fan Start/Stop | | | | 2 |

## 45.3 Sequence of Operation for Fresh Air-Handling Units

45.3.1 Automatic temperature control of supply air, at user defined set point, 2 way chilled water control valve will respond to signal received from supply air temperature sensor installed in supply air duct.

45.3.2 Motorized damper shall be operated accordingly, during operation of AHU,s otherwise spring return damper close the air circulation path.

45.3.3 Discharge air sensor shall act as fire-stat. It will monitor the discharge air temperature, and upon its higher than the user specified limits the respective AHU shall be brought to fail safe condition.(Alarm shall generated on BMS)

45.3.4 Differential Pressure Switch, installed for filter status shall monitor the pressure drop across filter, when pressure drop across the filter increases from set point, the alarm indication shall be initiated at DDC Display and on BMS display.

45.3.5 Differential Pressure Switch, installed for fan status shall monitor air flow, in case of air flow failure the fan, an alarm indication shall be indicated at DDC Display and on BMS Display.

DDC Point Summary Chart for each FA-AHU (2 Nos)

| Description | AI | DI | AO | DO |
|---|---|---|---|---|
| Out Side Air Temperature | 1 | | | |
| Out Side Relative Humidity | 1 | | | |
| Supply Air Temperature | 1 | | | |
| Smoke Detector | 1 | | | |
| Air Filter P.D | | 1 | | |
| Two Way Motorized Valve | | | 1 | |
| Supply Air Fan P.D | | 1 | | |
| Chilled Water Temp In/Out | 2 | | | |
| Motorized Damper Actuator (0-100 % Adjustment) | | | 2 | |
| Variable Frequency Drive (0-100 % Adjustment) | | | 1 | |

## 45.4 1 No Chiller, 1 No Hot Water Heater, 8 Nos Pumps

DDC Point Summary Chart

| Description | AI | DI | AO | DO |
|---|---|---|---|---|
| Out Side Air Temperature | 1 | | | |
| Out Side Relative Humidity | 1 | | | |
| Chilled Water Temperature In/Out | 4 | | | |
| Hot Water Temperature In/Out | 4 | | | |
| Condenser Water Temperature In/Out | 4 | | | |

| | | | | |
|---|---|---|---|---|
| Chiller Start/Stop | | | | 2 |
| Hot Water Heater Start/Stop | | | | 2 |
| Primary Chilled Water Pump Status | | 3 | | |
| Primary Chilled Water Pump Start/Stop | | | | 3 |
| Secondary Chilled Water Pump Status | | 3 | | |
| Variable Frequency Drive (0-100 % Adjustment) for SecondaryChilled Water Pump. | | | 3 | |
| Secondary Chilled Water Pump Start/Stop | | | | 3 |
| Condenser Water Pump Status | | 3 | | |
| Condenser Water Pump Start/Stop | | | | 3 |
| Chilled Water Flow Switch | | 2 | | |
| Hot Water Flow Switch | | 2 | | |
| Condenser Water Flow Switch | | 2 | | |
| Water Pressure Transmitter | 2 | | | |

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## 46. INSTRUMENTATION

### GENERAL DISCRIPTION

All instrumentation shall be mounted such that it can be read from a normal access position. Orientation and sizes of gauges etc. shall be such that the readings can be observed from normal standing position at floor level or fixed walkways etc. Where this is not possible due to mounting height or congestion of services, remote gauges shall be used, mounted in groups on a panel and clearly labelled to identify the function and location of the sensor etc. Instrumentation shall not be installed in any location that protrudes into designated access ways, restricts access, and becomes a tripping or snagging hazard.

### CONTROL FUNCTION

The BMS control system shall provide control and monitoring of the following MEP devices:-

Chillers with Primary & Secondary Variable Chilled Water System along with Cooling Towers & Condenser Water Pumps

#### 1. Chillers with Primary & Secondary Variable Chilled Water System

The chilled water system consists of water cooled chillers, primary chilled water pumps-constant speed and Secondary Pumps VFD Driven. These pumps shall receive the 'start / stop' command from the BMS only if the 'hand – off – auto' switch of all these pumps is in 'auto' position. The 'run' status and the 'trip' status of the pumps are monitored via volt-free contacts from the motor control centers. The fault signal and the feedback signal from the VFDs of the Secondary Pumps are monitored.

Butterfly valves are located on both condenser & evaporator side of the chiller. Upon call for cooling as sensed by the immersion temperature sensor located in the common chilled water supply line the DDC controller opens the butterfly valve first and then starts the primary pump the limit switch located in the butterfly valve closes to prove the open status of the butterfly valve. On receipt of this signal the DDC enables the chiller to start.

When the lead chiller is fully loaded and upon a call for further cooling (as again sensed by the Common Return CHW Temperature sensor) the second chiller is signaled to run by the BMS as per the sequence defined above.

The 'run' and the 'common fault' signal form the chiller shall be made available to the BMS through the volt free contacts from the chiller control panel.

With reducing load, the 2 port valves in the AHU and FCUs shall move towards the close position thereby increasing the pressure in the supply header line as sensed by the immersion pressure sensor. On Sensing this changes in pressure the DDC Controller shall reduce the speed of the Secondary Pumps via the Variable Frequency Drives.

A bypass (De-coupler) line shall be provided as an interface between the Primary Chilled Water System and the Secondary Chilled Water System. Since the primary pumps are constant flow pumps, with a decreasing load the excessive water quantity passes through the bypass line, increasing the pressure in the line as sensed by the differential pressure sensor. The reduction in flow in the main supply header is sensed by the flow meter provided.

Also once the reduction in flow (as measured by the flow meter) becomes equal to flow across one chiller the BMS disable one chiller, the associated pump and closes the butterfly valve.

The process repeats itself to meet the required conditions.
With increasing load the Chilled water shall move from the bypass line into the Secondary circuit and increases the supply temp as measured by the temp sensor after the bypass on the supply line. When this increase in load as measured by the flow in the Supply line becomes equal to flow of water across one chiller the BMS opens the butterfly valve, and once the valve is proven open the chilled water pump is started and chiller enabled so as to

maintain the desired temperature differential.

The process repeats itself to meet the required conditions.

The return chilled water temperature on both sides of the bypass & supply temperature after bypass are monitored by the BMS. Individual chiller leaving temperatures are also monitored.

## 2. Condenser Water Circuit

The Condenser Water Circuit comprising of Condenser Water Pumps & Cooling Towers.

For the condenser water circuit, the DDC shall control and monitor condenser water pumps and the cooling towers. The condenser pumps shall be constant speed pumps. The "AUTO" position of the H-O-A switch for the pumps is monitored by the DDC to ensure automatic operation only if the switches are in “auto” positions. The DDC shall also monitor the trip & run status.

The BMS shall allow for automatic duty sharing of the condenser water pumps to ensure equal wear and tear.

The cooling towers shall be with variable speed drive fan motors. The "AUTO" position of the H-O-A switch for the fans is monitored by the DDC to ensure automatic operation only if the switches are in “auto” positions. The DDC shall also monitor the variable speed drive trip status and control the cooling tower fan speeds by giving 0-10 v dc outputs for the cooling tower fan motor. The DDC shall also receive the fan speed feedback via 0-10 v dc from the variable speed drive of the cooling tower fan motor.

The cooling towers shall be provided with motorized butterfly valves on both inlet & outlet side. At the start-up, when the cooling demand is established and when all the equipments are in ‘auto’ mode, the DDC shall first open the motorized butterfly valve on both sides of the cooling tower. A limit switch located in the butterfly valve closes to prove the open status of the butterfly valve. On receipt of this signal, the DDC enables the condenser water pumps and also enables the cooling tower fan motor to start.

The DDC shall also monitor the common condenser water supply and return temperatures. Based on the temperature difference between the condenser water entering and leaving water, the DDC shall first reduce the cooling tower fan motor speed. On further reduction in load if one of the chillers is disabled by the BMS, the temperature difference in the condenser circuit reduces. Based on this, the BMS disables one cooling tower fan and also disables one condenser pump and the corresponding set of cooling tower butterfly valves are closed.

The process repeats itself to maintain the required temperature in the condenser water circuit. For each cooling tower Individual leaving water temperature is monitored.

The cooling tower sump water level shall be monitored via a differential pressure switch. High & low sump level alarms shall be generated via the software in the BMS.

Once the condenser water flow is established, the DDC shall sequence the chilled water circuit to start.

## 3. TYPICAL CONSTANT AIR VOLUME AIR HANDLING UNITS:

The Constant Air Volume system supplies conditioned constant airflow to the space to maintain temperature based on the set points.

The start /stop of air handling unit is based on time schedule and will be enabled when AHU supply fan starter panel is in Auto position. The Auto status of the starter panel is monitored on the BMS, which is hard wired to the DDC panel.

Once the AHU is enabled, the fresh air damper shall open and temperature control will enable on receipt of signal from fan DPS. When the AHU supply fan is off the fresh air damper will close and the 2 port chilled water control valve will drive to close position.

In case power fail to DOC, power fail restart logic should be applied. This logic will start the system from beginning, as if the equipment is being started for the first time in the day.

When the system is running in manual mode the temperature control loop shall enable on receipt of signal from DPS (Airflow switch).

## 3.1 AHU TEMPERATURE CONTROL:

The supply and return air duct temperature sensors will sense the supply and return air temperatures and transmits the signal to the DDC controller. The Controller then compares the read values with set point values and accordingly modulates (0-10vdc signal) the 2 port valves via modulating actuator in order to achieve the set point conditions.

Set Point Schedule:
Return Air (RA) Temperature : 22 °C
Supply Air (S.A) temperature : 18 °C
Return Air (RA) Temperature : 24 °C
Supply Air (S.A) Temperature :12.4 °C

The remote set point command to vary return air set point as required by BMS operator. The supply air temperature shall be maintained such that when the return air temperature falls, the supply air temperature can be raised, as per above schedule. This shall be programmed via a dynamic setting curve in increments of 0.5 °C RA temperature fluctuation and can be adjusted at the BMS.

## 3.2 AHU SAFETY CONTROL:

If the return air temperature is more than 28 °C and the supply air temperature more than 20 °C, an alarm shall be activated at the central workstation. In case of smoke detection, the duct smoke detector installed in the return air duct of the AHU and having a hardwired connection with the fire alarm system and hardwired interlock with the fan starter. The fan of the AHU will shutdown upon sensing smoke in ducts.

If the air differential pressure switch across the AHU supply fan will alarm at the DOC on no airflow condition (no-airflow within 120 seconds) the AHU shall shut down. The differential pressure switch also alarm at the DOC when the supply fan is set in the "OFF" position from the DOC and the airflow is detected.

## 3.3 AHU FILTER STATUS:

The AHU air filter is monitored via differential pressure switch fitted across the filters and in the event of filters become dirty the air differential pressure switch will give volt free signal to the controller and an alarm will be activated on the BMS.

## 3.4 AHU FIRE ALARM

In the event of fire alarm signal in any zone, AHU's will be shut down if not required to be operated as make up air unit otherwise shall remain operational and the smoke exhaust fan will start and exhausting the smoke in that area, which is via hardwired connection in the MCC panel. When the fire alarm is reset the air handling unit will be enabled automatically based on the program on the reset condition and the fan will run in normal mode. The above operation will be automatically commanded from Fire Alarm Panel.

Also, the BMS will command the AHU supply fan to stop if not required to be operated as make up air unit otherwise shall remain operational.

## 4. TYPICAL VARIABLE AIR VOLUME AIR HANDLING UNITS

The start /stop of air handling unit is based on time schedule and will be enabled when AHU supply fan VFD is in Auto position. The Auto status of the VFD starter is monitored on the BMS, which is hardwired to the DOC panel. Once the AHU is enabled at minimum speed, the fresh air damper shall open and temperature control will enable on receipt of signal from fan DPS. When the AHU supply fan is off the fresh air damper will close and the 2 port chilled

water control valve will drive to close position.

In case power fail to DOC, power fail restart logic should be applied. This logic will start the system from beginning, as if the equipment is being started for the first time in the day.

## 4.1 SYSTEM DESCRIPTION:

The air handling unit is with variable frequency drive providing variable air volume with controlled temperature air supply and controlled demand ventilation to modulate air supply based on the space temperature and the outdoor air supply based on the occupancy.

The controlled demand ventilation is achieved thru the fresh air modulating damper which shall ramp up or ramp down to modulate the outdoor air supply at signal received from the C02 sensor mounted on the AHU return duct

## 4.2 DEMAND CONTROLLED VENTILATION:

The C02 sensor mounted in the return main air duct of the AHU shall relay the input to the DDC controller. In case, the return air C02 is higher than the setpoint of 500 ppm (adjustable), the DDC controller shall give modulating outputs to the modulating dampers of the treated outdoor air and the exhaust air to ramp up above the minimum positions. In case, the return air C02 is less than the setpoint of 500 ppm (adjustable), the DDC controller shall give modulating outputs to the modulating dampers of the treated outdoor air and the exhaust air to ramp down to the minimum positions . This process shall continue till the return air C02 level reaches 500 ppm (adjustable). In case the C02 level remains above 750 ppm continuously for a period of 5 minutes, an alarm shall be generated by BMS.

## 4.3 AHU TEMPERATURE CONTROL

The supply and return air duct temperature sensors will sense the supply and return air temperatures and transmits the signal to the DDC controller.

The Controller then compares the read values with set point values and accordingly modulates (0-10 Vdc signal) the 2 port valves via modulating actuator in order to achieve the set point conditions.

Set Point Schedule:

Return Air (RA) Temperature : 22 °C
Supply Air (S.A) temperature : 18 °C
Return Air (RA) Temperature : 24 °C
Supply Air (S.A) temperature : 12.4 °C

The supply air temperature shall be maintained such that when the return air temperature falls, the supply air temperature can be raised, as per above schedule. This shall be programmed via a dynamic setting curve in increments of 0.5 °C RA temperature fluctuation and can be adjusted at the BMS.

## 4.4 AHU DUCT PRESSURE CONTROL

The static pressure sensor installed 2/3rd down stream on the supply air duct and will be monitor the duct static pressure and transmits the signal (0-10 Vdc) to its respective DDC controller. The controller then compares actual pressure (read value) with set values and accordingly gives an modulating output signal (0-10 Vdc) to the AHU VFD which in turn will modulate to vary the supply air volume to achieve the set point conditions. Monitor the VFD RPM and display in the central.

## 4.5 AHU SAFETY CONTROL

If the return air temperature is more than 28 °C and the supply air temperature more than 20 °C, an alarm shall be activated at the central workstation. In case of smoke detection, the duct smoke detector installed in the return air

duct of the AHU and having a hardwired connection with the fire alarm system and hardwired interlock with the fan starter. The fan of the AHU will shutdown upon sensing smoke in ducts.

The Duct pressure sensor in the 2/3rd down stream of supply duct will alarm at the DOC when the duct pressure changes above high-high level (time limit within 120 seconds) and it will shut down the AHU and initiate maintenance instructions.

The air differential pressure switch across the AHU supply fan will alarm at the DOC on no airflow condition (no-airflow within 120 seconds) and it will shut down the respective AHU. The differential pressure switch also alarm at the DOC when the supply fan is set in the "OFF" position from the DOC and the airflow is detected.

### 4.6 AHU FILTER STATUS

The AHU air filter (primary and final filters) are monitored via differential pressure switch fitted across the filters and in the event of filters become dirty the air differential pressure switch will give volt free signal to the controller and an alarm will be activated on the BMS.

### 4.7 AHU FIRE ALARM

In the event of fire alarm signal in any zone, AHU's will be shut down if not required to be operated as make up air unit otherwise shall remain operational and the smoke exhaust fan will start and exhausting the smoke in that area, which is via hardwired connection in the MCC panel. When the fire alarm is reset the air handling unit will be enabled automatically based on the program on the reset condition and the fan will run in normal mode. The above operation will be automatically commanded from Fire Alarm Panel.

Also, the BMS will command the AHU supply fan to stop if not required to be operated as make up air unit, otherwise shall remain operational.

## 5. Typical Constant Air Volume (or Outdoor) Air Handling Units

These units provide treated cooled and dehumidified fresh air.

These units shall deliver air at room temperature 23°CDB/17°C WB.

These units If specified with heat recovery wheels shall operate to recover heat from toilet exhaust air stream whenever the enthalpy of the toilet exhaust air is 5% lower or 5% higher than the ambient air enthalpy.

These units if specified with run around cycling coils or heat pipe coiling systems shall operate to extract heat from the air prior to the cooling coil whenever the air temperature is above the delivery conditions. Cooling coil control *valve* shall modulate to achieve final delivery dry bulb temperature and operate as a dehumidifier to achieve final moisture content set point (0.0095 kg water per kg dry air). Run around cycling coils or heat pipe then adds dry heat back into air to achieve final delivery conditions.

The start /stop of air handling unit is based on time schedule and will be enabled when (FAHU or OAHU) supply fan starter panel is in Auto position. The Auto status of the starter panel is monitored on the BMS, which is hard, wired to the DOC panel.

Once the (FAHU or OAHU) is enabled temperature control will enable on receipt of signal from fan DPS.

### 5.1 FAHU FIRE ALARM

In the event of fire alarm signal FAHU will be shut down if not required to be operated as make up air unit otherwise shall remain operational and the smoke exhaust fan will start and exhausting the smoke in that area, which is via hardwired connection in the MCC panel.

A direct stop command to fan from the BMS operator if not required to be operated as make up air unit otherwise

shall remain operational.

### 5.2 FAHU Temperature Control

The supply air duct temperature sensors will sense the supply air temperatures and transmits the signal to the DDC controller.

The Controller then compares the read values with set point values and accordingly modulate (0-10 V dc signal) the 2 port valves via modulating actuator in order to achieve the set point conditions.

### 5.3 FAHU Safety Control

The supply air temperature (more than 30 dec.C) will signal an alarm at the central workstation. The duct type smoke detector shall be installed in supply air duct of the FAHU. This smoke detector shall be connected with Fire Alarm network and hard wire interlock with Fan Starter. The FAHU will shut down on sensing smoke in the supply air.

The air differential pressure switch across the FAHU supply fan will alarm at the DDC on no airflow condition (no-airflow within 120 seconds} and it will shut down the respective FAHU. The differential pressure switch also alarm at the DDC when the supply fan is set in the "OFF" position from the DDC and the airflow is detected.

### 5.4 FAHU Filters

The air filters (both primary and final filters) are monitored via differential pressure switch fitted across the filters and in the event of filters become dirty the air differential pressure switch will give volt free signal to the controller and an alarm will be activated on the BMS.

### 5.5 FAHU Fresh Air Temperature and Humidity

The temperature and humidity sensors mounted in the fresh air intake will monitor and display the (ambient Air) temperature and humidity on the BMS.

The temperature and humidity sensors mounted in the fresh air supply will monitor and display the fresh air temperature and humidity on the BMS and provides the feedback signals to modulate operation of cooling and dehumidification coils.

## 6. Typical Variable Air Volume Fresh Air (or Outdoor) Air Handling Units

These units provide treated cooled and dehumidified fresh air.

These units shall deliver air at room temperature 18°CDB/14°C WB.

These units are with heat recovery wheels shall operate to recover heat from toilet exhaust air stream whenever the enthalpy of the toilet exhaust air is 5% lower or 5% higher than the ambient air enthalpy.

These units with run around cycling coils and heat pipe coiling systems shall operate to extract heat from the air prior to the cooling coil whenever the air temperature is above the delivery conditions. Cooling coil control *valve* shall modulate to achieve final delivery dry bulb temperature and operate as a dehumidifier to achieve final moisture content set point (0.0095 kg water per kg dry air). Run around cycling coils or heat pipe then adds dry heat back into air to achieve final delivery conditions.

The start /stop of the fresh air handling unit is based on time schedule and will be enabled when supply fan VFD is in Auto position. The Auto status of the VFD starter is monitored on the BMS, which is hardwired to the DOC panel. Once the AHU is enabled at minimum speed, the fresh air intake damper shall open and temperature control will enable on receipt of signal from fan DPS.

When the fresh air supply fan (System) is OFF, the two port chilled water valves shall modulate to the full closed

position. This can be initiated by the following conditions:

### 6.1 Fan Speed

The fan is designed as variable speed in order to serve AHUs with outdoor preconditioned air under the requirements of the controlled demand ventilation.

The supply fan should operate to vary the amount of supply air and as well the exhaust fan to *vary* the amount of the exhaust air and therefore, 2 Nos. variable frequency drivers are required, one for the supply fan and one for the exhaust fan.

### 6.2 FAHU Temperature Control

The supply air duct temperature sensors will sense the supply air temperatures and transmits the signal to the DDC controller. The Controller then compares the read values with set point values and accordingly modulate (0-10 V dc signal) the 2 port valves via modulating actuator in order to achieve the set point conditions.

### 6.3 FAHU Safety Control

The supply air temperature (more than 25 deg.C) will signal an alarm at the central workstation. The duct type smoke detector shall be installed in supply air duct of the FAHU. This smoke detector shall be connected with Fire Alarm network and hard wire interlock with Fan Starter. The FAHU will shut down on sensing smoke in the supply air.

The air differential pressure switch across the FAHU supply fan will alarm at the DDC on no airflow condition (no-airflow within 120 seconds) and it will shut down the respective FAHU. The differential pressure switch also alarm at the DDC when the supply fan is set in the "OFF" position from the DOC and the airflow is detected.

### 6.4 FAHU Duct Pressure Control

The static pressure sensor installed 2/3rd down stream on the supply air duct and will be monitor the duct static pressure and transmits the signal (0-10vdc) to its respective DDC controller. The controller then compares actual pressure (read value) with set values and accordingly gives an modulating output signal (0- 10Vdc) to the FAHU VFD which in turn will modulate to vary the supply air volume to achieve the set point conditions. Monitor the VFD RPM and display in the central.

### 6.5 FAHU Filters

The FAHU air filters (both primary and final filters) are monitored via differential pressure switch fitted across the filters and in the event of filters become dirty the air differential pressure switch will give volt free signal to the controller and an alarm will be activated on the BMS.

### 6.6 FAHU Fire Alarm

In the event of fire alarm signal in that zone, FAHU's will be shut down if not required to be operated as make up air unit otherwise shall remain operational and the smoke exhaust fan will start and exhausting the smoke in that area, which is via hardwired connection in the MCC panel. When the fire alarm is reset the air handling
unit will be enabled automatically based on the program on the reset condition and the smoke exhaust fan will stop running. The above operation will be automatically commanded from Fire Alarm Panel.

Also, the BMS will command the FAHU supply fan to stop if not required to be operated as make up air unit otherwise shall remain operational.

## 7. STAIR CASE AND LIFT PRESSURIZATION FANS

The BMS shall also allow the operator to run these fans only for maintenance purposes as per the time program or operator override from the DDC controller.

The BMS shall provide an enable / disable signal to the local control panel based on the program or operator override from the DDC controller. This will only possible when the hand-off- auto switch is in 'auto' position. The 'Run'· status of the fan shall be monitored on BMS via the Airflow Switch and auxiliary contact in the control panel. The 'overload trip' status of these fans shall also be monitored by the BMS vial volt free contacts from the control panel. However, the Fire Alarm System shall have override control of these fans.

The DDC controller shall monitor the status of Dampers and in case of Fire Alarm signal as transmitted to it by fire Alarm Panel, the DDC Controller shall close the Dampers.

### 7.1 Exhaust Fan (Constant Speed)

The constant speed exhaust fans are complete with a built-in auto-changeover and duty sharing control panel if are of twin arrangement, supplied completely tested and pre-wired with an integral control panel ready for installation and operation by the equipment supplier. BMS will operate the constant speed exhaust fan during the occupancy period as per the schedule.

An alarm signal initiated by any fire alarm zone will command the exhaust fans to stop if the fan is not used for smoke exhaust or make up air during fire.

For duty and standby arrangement each fan is monitored separately but with automatic changeover and duty sharing control panel.

## 8. WATER SUPPLY PUMP SETS

A dedicated control panel will operate these pumps.

The pump control panel will transmit VFC signals to the DDC controller to monitor the Common fault and Run status. On receipt of these signals, the DDC controller will generate the respective status/alarm indication at the BMS.

## 9. WATER TANKS

The water tank is partitioned. The levels of both partitions are indicated to the BMS via level transducers. The high and low level alarms shall be monitored via software.

Energy Monitoring Unit:

EMUs shall be provided for all the HV and LVMDB's as shown on single line diagrams. These shall be communicating on the MOD bus protocol and integrated directly with the BMS. EMU shall provide voltage, currents for each phase. EMU shall also transmit to BMS other relevant parameters such as frequency, power factor, active power, reactive power, instantaneous Kw, harmonic analysis etc. provide separate harmonic analyzer if required. ACBs shall operate with BMS using MOD bus protocol.

Transducers are provided in the power feeders to specific areas as shown on electrical single line diagrams. These shall be connected to BMS to compute the energy consumption respective areas.

## 10. GENERATOR PANEL:

The Generator shall be integrated to BMS via software.

The fuel levels in Main Fuel Tank & Daily Fuel Tank shall be monitored. The volt free contacts shall be transferred to BMS and High & Low alarms shall be generated. The tanks shall have inbuilt level sensors.

## 11. LIFTS / ESCALETTERS

A dedicated control panel will operate Lifts / Escalators. The control panel will transmit VFC signals to the DDC

controller to monitor the following status:

- Lift Run status
- Cabin Call Alarm
- Common Fault Alarm

## 12. FIRE ALARM INTERFACE:

Complete Fire Alarm system shall be integrated to BMS using BACnet protocol.

Fire Fighting System Interface:

Complete Fire Alarm system shall be integrated to BMS using BACnet protocol.

## DATA POINT SCHEDULE

Contractor to ensure that respective systems provides the soft/hard interface units for the BMS interface as per BMS requirements below. Also, BMS vendor to make sure all specific interphase units mentioned in the project specification for the respective system are also interfaced.

### 1. Chillers

Chiller start / stop
Chiller run status
Indication of manual switch position
Chilled water temperatures IN / OUT
Condenser water temperatures IN / OUT
Chiller trip alarm
Butterfly valve open / close

### 2. Cooling Towers

Cooling towers start / stop
Cooling tower run status
Indication of manual switch position
Condenser water temperatures IN / OUT
Cooling tower trip alarm
Cooling tower fan speed
Butterfly valve open / close

### 3. Chilled Water Primary Circuit (Typical)

H-O-A Selector Switch
Pumps Start / Stop Command
Pump Run Status
Pump Trip Alarm

### 4. Chilled Water Secondary Pump (Typical)

HOA selector switch status
Pump/VFD Enable/Disable
Pump/VFD Run status

Pump/VFD Trip Status
VFD Speed Feedback
VFD Speed Control
Differential pressure sensor

**5. Fresh Air AHU with Thermal Wheel (Typical)**

Fresh Air Damper Open/Close Command
Fresh Air Damper Open/Close Status
Extract Air Damper Open/Close Command
Extract Air Damper Open/Close Status
Pre-Filter Dirty Alarm
Bag Filter Dirty Alarm
HOA Switch Auto Status (Supply & Extract)
Fan Start/Stop Command (Supply & Extract)
Fan Run Status (supply & extract)
Fan Trip Status (supply & return)
On Cooling Coil Temperature (DB/WB)
Off Cooling Coil Temperature (DB/WB)
Heat Recovery Wheel Start/stop command
Heat Recovery Wheel Run status
Heat Recovery Wheel Trip status
Temperature (DB/WB) of Air after Heat Recovery Wheel
Heating Coil Status
Heating Coil Trip Alarm
Supply Air Temperature (DB/WB)
Return Air Temperature (DB/WB)
C.W. Control Valve Modulating Command
Fire Alarm Signal

**6. Constant Speed Recirculating AHU's (Typical)**

Fresh Air Damper Open/Close Command
Fresh Air Damper Open/Close Status
HOA switch auto status
Fan start/stop command
Fan run status
Fan trip status
Pre-Filter Dirty Alarm
Bag Filter Dirty Alarm
C.W. Control Valve Modulating Command
Supply Air Temperature (DB/WB)
Return Air Temperature (DB/WB)
Fire alarm signal
Off Cooling Coil Temperature (DB/WB)
Heating Coil Status
Heating Coil Trip Alarm

**7. Recirculating Air Handling Unit With VFD VAV (Typical)**

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Fresh Air Damper Open/Close Command
Fresh Air Damper Open/Close Status
HOA switch auto status
Supply Fan VSD Enable/Disable
Supply Fan VSD Speed Control Command
Supply Fan VSD Speed Feedback
Supply Fan VSD Trip Status
Supply Fan Run Status
Pre-Filter Dirty Alarm
Supply Duct Pressure
Return Air Temperature (DB/WB)
Supply Air temperature (DB/WB)
C.W. Control Valve Modulating Command
Fire Alarm Signal
Off Cooling Coil Temperature (DB/WB)
Heating Coil Status
Heating Coil Trip Alarm

## 8. Extract Air / Makeup Air Fan (Typical)

HOA switch auto status
Fan start / stop command
Fan run status
Filter status
Fan trip status
Motorized damper status

## 9. Smoke Extract Air Fans (Typical)

HOA switch auto status
Fan run status
Fan trip
Fire alarm
Motorized Damper status
Fire / Smoke Damper Status

## 10. Staircase Pressurization Fans (AHU - Typical)

HOA switch auto status
Fan Start/ Stop Command
Fan run status
Fan VFD Speed Control Command
Fan VFD Speed Feedback
Fan trip status
Motorized Fire Damper On/Off Damper status

## 11. Water Supply Pump system (Typical)

Pump Selection Status
HOA switch auto status
Water pump run status

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Karachi
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PROJECT MANAGEMENT
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Water tank levels
Pump start/ stop Command
Water supply pump trip status
High / Low Water Level Alarm

## 12. Fire Reservoir Monitoring

Tank level indication
High / Low Water Level Alarm

## 13. Diesel Tank (Above Ground) Monitoring

Tank level indication
High / Low Fuel (Diesel) Level Alarm

## 14. Fire Pump Set

Power On
Electrical Fire Pump Run Status
Electrical Jocky Pump Run Status
Diesel Fire Pump Run Status
Battery Healthy Status
Stand pipe Loop Pressure monitoring
Wet fire riser top Pressure monitoring
Low Water pressure Alarm

## 15. Generator Fuel System

Daily Tank Fuel Level
Main Tank Fuel Level
High / Low Fuel (Diesel) Level Alarm

## 16. Electrical LV Panel Monitoring

Energy Monitoring for HV, LV MDBs (Typical)
Energy Monitoring for Generator Panel
LV Incomer status
LV Outgoing status
LT Panel Busbar Temperature Monitoring
LT Room temperature Monitoring
LT Room Fire/Smoke detection
Interface complete data/status from Novec 1230 clean agent operating panel

## 17. Lift Monitoring

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Lifts (Typical)
Lift Run Status
Cabin Call Alarm
Common Fault Alarm

### 18. Fire Alarm System

Interface complete data/status from Fire Alarm Panel

### 19. Communicating FCU for Detailed & Common areas

LON dedicated controller for each FCU with return sensor control / room control unit

## BMS NETWORK AND STRUCTURED CABLING SYSTEM

BMS network shall be established using the Structured Cabling System. This shall be supplied by the specialist structured cabling system vendor, as part of the MEP contractors scope of work. This shall be Level 4 type or higher as per latest standards for LON systems and Cat – 6, UTP for BACnet systems. Cables. F.O. Cables, Active Components, Termination, etc shall be provided for a high speed network connection.

The proposed Structured cabling system vendor shall be same as the vendor for telecommunication System.

BMS submittal without the design of BMS Structured Cabling System shall not be acceptable. Cable selections shall meet individual requirements as set out by the protocols.

- End of Section -

# FIRE PROTECTION SYSTEM WORKS

# FIRE PROTECTION SYSTEM

## 1. Design Intent

The building will be provided with fire protection systems generally complying with international standards, comprising but not limited to the following:

a. Fire Cabinets at strategic locations within the buildings, containing the following:

1) One DN 65 (2-1/2 inch) landing valve with or without pressure reducing capability.
2) One DN 25 (1 inch) 30m long, first aid fire hose reel.
3) One 6 Kg Water/Gas Fire Extinguisher.
4) One 6 kg, Carbon Dioxide Portable Fire Extinguisher.

b. Sprinkler systems, controlled by (ZCR) Zone Control Valves or Installation ControlValves.
c. Automatic deluge and/or foam systems for protection of electrical transformers.
d. Roof manifolds with minimum two DN 65 (2-1/2 inch) landing valves for verifyingsystem capacity.
e. Fire Brigade breaching units, located in strategic locations to enable Fire Brigadedefenders to supply water to the building systems.
f. Clean agent fire protection systems will be provided for computers, Data Cabinet, UPS MDF/Data Center, Telephone Exchange.

Requirements of the Pakistan Fire Department (authority having Jurisdiction) will be conformed to as appropriate.

Fire Alarm and Fire Fighting provisions will be required, as per Pakistan Fire Department requirements.

Special fire protection systems: computers, BMS, MDF/Data Center, electrical and control rooms will be protected with special systems as appropriate and warranted and in accordance with Pakistan Fire Department requirements.

Clean agent fire protection systems will be provided for computers, BMS, MDF/Data Center.

The Buildings shall have full Sprinkler Coverage by a Wet Pipe Fire Sprinkler System with combination Stand Pipes in each stairwell. Each stairwell landing shall include a DN 65 Fire Department Landing Valve and Sprinkler Zone Valves connected to the Stand Pipe. A roof monitor shall be included at the top of each standpipe. All Fire Service Valves flow/pressure shall be monitored and Supervised through Building/Energy Management System.

Reserve water for Firewater, domestic water, and cooling tower make-up shall be stored using a common underground water storage tank. Fire reserve (60-90 minutes operation of the largest sprinkler system plus two DN 65 [2-1/2 inch] hose streams) will be maintained in the fresh water storage tanks, by mechanically and electrically preventing the boosted pump sets from operating below the Fire reserve level.

Fire Pumping System, comprising the following, will be used to deliver pressurized water to the various Fire protection systems:

a. Electric motor driven and diesel engine driven pumps: Capable of providing residual pressure of 45 m (65 psig) at the hydraulically remote fire hydrant valve within the building.
b. Electric motor driven jockey (pressure maintenance) pump.

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Below grade, fire protection water distribution piping network: For supplying pressurized water to external hydrants, combined wet hydrant and sprinkler systems or separate wet hydrant/sprinkler systems.

Irrigation storage water system shall be separate from this Fire/Domestic water tank. Water shall be pumped from this tank for distribution throughout the facility. Combined water service and fire service piping shall be designed to comply with codes for both plumbing and fire service authoritieshaving jurisdiction.

FIRE PUMP SET Section- 74:01

## GENERAL

### 1. SCOPE OR WORK

1.1 Supply, Testing, Commissioning of pump sets as shown on drawings and specified herein & as per instruction of Consultant and General Instructions for Fire Fighting System as mentioned in Section 74:01.

1.2 The Pump Head shown on the drawing and schedule is an estimated. The Fire Protection Contractor shall select a pump head to satisfy the Fire Protection system requirement based on the system Hydraulic Calculation.

1.3 The Pumps Drivers, all Controls and necessary attachment, specified herein, shall be a single contract as a single unit.

## TECHNICAL DESCRIPTION

### 2. CENTRIFUGAL, HORIZONTAL, END-SUCTION FIRE PUMP

2.1 The Centrifugal Horizontal Water Pump-Set/End Suction, horizontal split casing, single or multi stage, Overhung impeller design and impeller between bearing design, Close Couple/separately coupled with flexible coupling, specifically labeled single skid mounted for Fire Service. Design shall be UL or ULC Listed and FM Approved and as per NFPA-20 Standards or approved equal horizontal, split casing rated to withstand twice the working pressure, complete with pump with Electric motor and Diesel engine drive, Gate Valve at suction Line, Non Return Valve, Gate Valve on Discharge Header, Gate Valve at Test Header-up stream, Flow Meter, Gate Valve at Test Header-Down Stream, Jockey Pump with Gate Valve at both end, Electric Controller, Diesel Controller, Non return Valve – Jockey pump, Pressure sensing equipment, Flexible coupling, frame, RCC foundation, Starters, Controller suitable electric motor, discharged and suction connection with valves and test facility, accessories as per typical connections of pumps for specified application confirming the pump curves certifying pump operation, BHP & NPSH curves shall be submitted to the consultant for approval.

2.2 The Fire Pump and System shall include:

2.2.1 One ventilation type flow metering device shall be provided for each pump.
2.2.2 Air Release Valve and Fittings, Valves with supervisory switch.

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2.2.3 Circulation Relief Valve, Pilot operated, Enclosed Relief Valve Over flow Cone and Discharge Tee with Elbow for Diesel drive .

2.2.4 Main Relief Valve with Discharged Pipe to storage tank.

2.2.5 Pump casing Relief Valve.

2.2.6 Eccentric tapered reducer at suction inlet.

2.2.7 Pipe Line Strainer.

## 3. GENERAL SPECIFICATION

3.1 All parts shall have a name plate indicating the proper name of manufacturers, make, model, serial no, for pump flow, total head, for motor listed horsepower, operating voltage, FLA, for diesel engine listed horsepower rating etc.

3.2 The Pumping unit shall meet all the requirements of the NFPA-20.

3.3 The pump and driver shall be mounted on a common grouted base plate.

3.4 The Pump shaft capable to deliver not less than 150% of rated capacity at a pressure ofnot less that 65% of rated pressure. The shutoff pressure shall not exceed 140% of the rated pressure at rated capacity.

3.5 The Pump shall be connected to the Stand Pipe System.

3.6 The Suction supply for the Fire Pump shall be from a Fire Reservoir/Tank at a maximum pressure of 20 kpa and a minimum pressure of 0 kpa.

## 4. TECHNICAL SPECIFICATION

**Pump and driver shall be from approved make.**

4.1 Driver Connection and Alignment, The pump and driver shall be connected by a listed closed coupled, flexible coupling and timing gear type coupling.

4.2 The pumps shall be suitable for quite and continuous operation at actual head and discharge,the pumps shall be single stage, horizontal split case non-loading, cast iron body, volute type.

4.3 The casing as per and bearing housing shall be of cast iron, ASTM A48 CI 40 highest point in the casing should be provided with air vent and lowest point should be provided with drainplug.

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4.4 The Impeller shall be Bronze SAE 40 and double shrouded type.

4.5 The Shaft Sleeve shall be AISI 420.

4.6 The Shaft Seal shall be Soft-packed stuffing box with Graphite impregnated type gland packing.

4.7 The Impeller guide glands, stuffing box ring, and shaft sleeve shall be of stainless steel.

4.8 The Shaft shall be of stainless steel, turned and ground.

4.9 The Bearing frame assembly of the pump should be fitted with re-greasable ball bearing equivalent to electric motor's bearing standard.

4.10 The pump and motor shall be mounted on a common base plate of heavy structural steel through flexible coupling equipped with a suitable coupling guard.

4.11 The pump casing shall be designed to withstand a discharge head specified plus the static head on system plus 50% of total head, but not less 125 psi.

4.12 The electric motors shall be drip proof type provided with suitable starters and totally enclosed, fan cooled type with class "F" insulation and overload protection as per IP54 standards.

4.13 The pump shall be non-overloading at any point on the characteristic curve.

4.14 Suction Pressure Gauge -30 inHG-0-30PSI,Dia 4‖

4.15 Discharge Pressure Gauge 0-300PSI,Dia 4‖.

4.16 Casing Relief Valve at Electric Pump.

4.17 Automatic Air Release Valve.

4.18 The flexible connections shall be provided on suction and discharge of the pumps.

4.19 Flow Test Device, A positive displacement pump shall allow the test of the pump at its ratedcondition as well as the suction supply at the maximum flow available from the pump.

4.20 All Electrical Equipment and installation methods shall be complied with NFPA-70, NationalElectrical code.

4.21 All Power supplies shall be located and arranged to protect against damage by fire fromwithin the premises and exposing hazards.

4.22 All Power supplies shall have the capacity to run the Fire Pump on a continues basis.

4.23 Service connection shall be dedicated to the Fire Pump installation.

## 4. MECHANICAL DRIVER (DIESEL ENGINE) FOR FIRE PUMP

4.1.1 Diesel Engine drive shall be of compression ignition type.

4.1.2 The horsepower capability of engine, when equipped with pump, shall have a 4-hour min horsepower rating not less than 10% greater than the listed horsepower on the engine name plate.

4.1.3 Engine shall be acceptable for horsepower rating listed by the testing laboratory for SAE condition.

4.1.4 Engine shall be selected, a deduction of max 3% from engine horsepower rating at standard SAE conditions shall be made for diesel engines for each 300m of altitude above 91m and 1% from engine horsepower as corrected to standard SAE conditions shall be made for engine for every 10 Deg F above 77 Deg F ambient temperature.

4.1.5 Engine shall have a 4-hour minimum horsepower rating equal to or greater than the break horsepower required to drive the pump at its rated speed under any conditions listed for environmental conditions under pump load.

4.1.6 Engine Power Connection to Pump, connected to horizontal shaft pumps by means of a flexible coupling or flexible connecting shaft listed for this service. The flexible couplingshall be directly attached to the engine flywheel adapter or stub shaft.

4.1.7 Engine Control Governor, Engine shall be provided with a governor capable of regulating engine speed within a range of 10% between shutoff and maximum load condition of the pump.

4.1.8 The governor shall be field adjustable and to be set and secured to maintain rated pump speed at maximum pump load.

4.1.9 Electronic Fuel Management Control, Alternate Electronic Control Module, Engines that incorporate an electronic control module (ECM) to accomplish and control the fuel injection process shall have an alternate ECM permanently mounted and wired so the engine can produce its full rated power output in the event of a failure of the primary ECM.

4.1.10 ECM Voltage Protection, ECM,s shall be protected from transient voltage spikes reverse dccurrent.

4.1.11 Engine power output, The ECM(or its connected sensor) shall not, for any reason, intentionally cause a reduction in the engine‘s ability to produce rated power output.

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4.1.12 ECM Sensor, Any sensor necessary for the function of the ECM that effect the engine ability to produce its rated power output shall have redundant sensor that shall operate automatically in the event of a failure of the primary sensor.

4.1.13 ECM and Engine Power Supply, In the stand by position, the engine stand by battery shall be used for power the ECM.

4.1.14 Engine Over speed Control, Engine shall be provided with an over speed shutdown device. The over speed device shall be arranged to shutdown engine in a speed range of 10 to 20 percent above rated engine speed and to be manually reset.

4.1.15 Engine Running and Crank Termination Control, Engine shall be provided with a speed sensitive switch to signal engine running and crank termination. Power for this signal shall be taken from a source other than the engine generator or alternator.

4.1.16 Engine Supervision, A common supervisory signal shall be provided to the controller in the event of any failure, Such as Fuel injection failure, Low fuel pressure, Any primary sensor failure, Crank termination.

4.1.17 Instrumentation panel, All engine instruments shall be placed on front of engine, Such as Instrument Panel, Tachometer, Oil Pressure Gauge, Temperature Gauge.

4.1.18 Engine starting method, shall be equipped with a reliable starting device and shall accelerate to rated output speed within 20 second.

4.1.19 Wiring Elements, All connecting wire for automatic controller shall be harnessed or flexibly enclosed, on the engine, and connected in an engine junction box to terminals numbered tocorrespond with the numbered terminals in the controller. All wiring on the engine, including starting circuitry, shall be sized on continuous-duty basis

4.1.20 Battery, Each engine shall be provided with two storage battery, Batteries shall be the maintenance free. Battery unit shall be sized on a calculated capacity of 72 hours of standby power followed by three 15-second attempt-to-start cycles, without ac power being available for battery charging. The battery cable shall be sized accordance with engine manufacturers recommendation considering the cable length required for the specific battery location. Current carrying parts shall not be less than 305mm above F.F

4.1.21 Engine Cooling System, the engine cooling system shall be close forced circulation watercooling system,

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A heat exchanger type that include a centrifugal driven by the engine, a heat exchanger,and an engine jacket temperature regulating device, cooling tower.

An opening shall be provided in the circuit for filling the system, checking coolant level andadding make-up coolant when required.

The coolant quality shall as per manufacturers recommendation.
A 3 way automatic valve listed for fire protection service shall permit flow of cooling waterto the engine when it is running.

4.1.22 A radiator type that includes a circulating pump driven by the engine, a radiator, an engine jacket temperature regulating device, an engine driven axial fan for providing positive movement of air through the radiator. The heat from the primary circuit of a radiator shall be dissipated by air movement through the radiator created by a fan included with, and driven by, the engine. The fan shall be capable of a 0.5 in. water column restriction created by the combination of the air supply and the discharge ventilators in addition to the radiator,fan guard.

4.1.23 Lubrication system consist of gear type oil pump driven by the gear of the cam shaft, paper element type oil filter, oil cooler composed of fins and pipe.

## 4.2 ELECTRIC DRIVE FOR FIRE PUMP

4.2.1 The Electric Motor shall be horizontal, open drip proof type, wound for 380 V, 50Hz. Motor shall be of such capacity that 120% of the full-load ampere rating shall not be exceeded at any condition of the pump load for a UL ambient temperature Listed Fire Pump.

4.2.2 The motor shall comply with NEMA MG-1, Motor shall be marked as comply with NEME Design B standards, and shall be specifically listed for fire pump service.

4.2.3 Part-winding motor shall have a 50-50 winding ratio in order to have equal currents in both winding while running at nominal speed.

4.2.4 Motor shall be rated for continuous duty.

4.2.5 Electric motor-induced transients shall be coordinated with the provision of, prevent nuisance tripping of motor controller protective devices.

4.2.6 The electric motors shall be drip proof type provided with suitable starters and totally enclosed, fan cooled type with class "F" insulation and overload protection as per IP55 standards.

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4.2.7 All electrical equipment shall comply rules of NFPA 70, National Electrical Code, Article 695 and other Applicable Article.

4.2.8 Power supplies shall have the capacity to run the fire pump on a continuous basis.

4.2.9 AN electric motor-driven fire pump shall be provided with a normal source of power as a continually available source.

## 4.3 FIRE PUMP MOTOR CONTROL EQUIPMENT

4.3.1 The Fire Pump motor control equipment shall be UL Listed, FM Approved. It shall be completely assembled, wired and tested by the control manufacturer before shipment from factory, and shall be BACnet/open protocol.

4.3.2 The controller shall be located as close as practical and within sight of the motor and shall be so located or protected that it will not be injured by water escaping from the pump or connection.

4.3.3 The controller shall be of the combined manual and automatic auto transformer type, and shall be complete with:

4.3.3.1 Disconnect switch-externally operate-able, quick-break type.

4.3.3.2 Circuit breaker-time delay type with trips in all phases set for 300% of the motor full-loadcurrent.

4.3.3.4 Motor starter, capable of being energized automatically through the pressure switch ormanual by means of an extremely operable handle.

4.3.3.5 Pressure switch, of adjustable type.

4.3.3.6 Running period timer-set to keep motor in operation, when started-automatically, for aminimum period of one minute for each 10HO motor rating, but not exceed 7 minutes.

4.3.3.7 Pilot lamp-to indicate circuit breaker closed and power available.

4.3.3.8 Ammeter test link and Voltmeter test studs.

4.3.3.9 Alarm relay to energize an audible or visible alarm through an independent source of power to indicate circuit breaker open or power failure.

4.3.3.10 Manual selection station-a two position station shall be provided on the enclosure marked ¯Automatic‖ and ¯Manual‖.

4.3.3.11 Mean shall be provided on the Controller to operate an alarm signal continuously while the pump is running.

4.3.3.12 Provision for power supply at 220V for diesel pump battery chargers.

4.3.3.13 Control equipment shall meet all requirement of NFPA 20.

4.3.3.14 Electronic water level indicator shall provide remote reading of water level. The LON

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compliant fire pump control panel shall have means for tank low water level input signal from IBMS and to shut down the pumps if the tank is empty.

## 4.4 JOKEY PUMP

4.4.1 The jockey pump capacity and pressure shall be as indicated in pump schedule on the drawings. The pump shall be 3000rpm close coupled, centrifugal, electric, and complete with pressure relief valve.

4.4.2 Pump controller shall be factory pre-wired and tested. Pressure switch shall sense low pressure in the fire pump system. Set cut-in pressure 5 psi above main fire pump cut-in pressure. Set cut-out pressure at system pressure. Provide minimum run timer to operate the pump for a minimum of 3 minutes.

4.4.3 Across the line start, H-O-A selector switch shall be integral to the control panel along witha fusible 3-pole disconnect switch, magnetic motor, contractor and thermal overload relays with external reset.

## 5. BUILDING MANAGEMENT SYSTEM (BMS) INTERFACE:

The Fire Pump controls with Integration Protocol shall be electronic based and capable of being interfaced with the BMS, and shall be able to communicate all data accessible from the keypad to a remote integrated ODC processor through a single shielded cable, this information will include all smoke detection, high temperature, pressures, safety alarms, and status readouts for complete integrated plant control, data logging, and local/remote display of operator information, start/stop the unit, etc., further the fire pump should accept the standard. Operating software shall be window based, and operating language must be English.

## 6. COMMISSIONING AND TESTING:

A Factory trained engineer provided by the supplier, duly authorized by the fire pump manufacturer, shall commission the whole system and give instructions at the site to the Owner operating personnel for a period of at least one weeks. The machine shall be commissioned as per manufacturer's procedures based on NFPA standard and the supplier shall furnish operating and safety control functions as mentioned. The manufacturer shall be subjected to recommend specified tests and these test reports shall be submitted to the Consultant by the supplier in suitable test forms.

## 7. EXECUTION

7.1 The Fire Pump shall be provided with a supervised isolating valve, flow meter and throttling valve on the test piping. Test piping shall discharge water to the fire water tank through a galvanized steel diffuser pipe.

7.2 Each fire pump shall be complete with suction and discharge pressure gauges, circulation relief valve, closed relief cone, automatic air release valve, drain valves coupling guard.

7.3 There shall be one control panel for the entire fire pump set.

7.4 A remote annunciation for each pump shall be located in the security office and shall provide the following features, diesel and electric pump status indicating lights and trouble light for each pump.

7.5 Batteries shall be furnished in a dry charge condition, with electrolyte liquid in a separate container. Electrolyte shall be added and the battery given a conditioning at the time that the engine is put into service. Batteries shall be located so as to readily accessible for servicing and at least 300mm above floor level.

7.6 The electric motor driven unit shall have the pump, electric motor and control panel mounted on a common base. The entire unit will be factory tested prior to shipping.

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7.7 The Control Panels shall be securely mounted in an enclosure which will protect the equipment against mechanical injury and falling drops of water. All switches requires to keep the controller in the ¯automatic‖ position shall be within the locked cabinet. Emergency access to the switch shall be by breaking the glass panel.

7.8 A wiring diagram shall be provided and permanently attached to the inside of the each enclosure showing exact wiring for the controller. Including a legend of identification numbers of individual components. All wiring terminals shall be plainly marked to correspond with the wiring diagram furnished.

7.9 Wiring elements of the controllers shall be designed on a continues-duty basis. All wiring leading from panel to the engine and to the batteries shall have adequate carrying capacity. All wiring must be protected against mechanical injury by metal conduit.

7.10 Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

### 7.11 Sequence of Operation

7.11.1 The electric Fire Pump shall be the lead pump. The Diesel Pump shall be back-up Fire pump and will only operate if the lead pump failure or not maintain system pressure.

7.11.2 The Jockey Pump shall maintain system pressure.

7.11.3 Field Acceptance test result shall be deemed to be as good as the manufacturer‘s certified shop test characteristics curve for the pump being tested within the accuracy limits of the test equipment and shall include test to demonstrate.

7.11.4 The Pump shall operate at peak load conditions without objectionable heating of thebearing or mechanical prime mover. The operating pumps speed shall be the speed at which the pumping unit would be expected to operate during a fire.

7.11.5 The Engine shall not show signs of overload or stress and its governor shall properly regulate the speed.

7.12 Field wiring of remote panels, installation and wiring of water level indicators, fuel piping shall be provided by the Fire Fighting Contractor.

7.13 The Qualified Commissioning Engineer shall provide field test reports to Consultant/Engineer and local Authorities having jurisdiction of satisfactory operation of the system. The pump manufacturers Engineer shall be at Site, supervising the tests.

## 8. FACTORY PERFORMANCE TEST

The Fire Pump shall be factory performance tested by the manufacturer as per described NFPA-20 under specified conditions in the presence of one representative each of the Client & two representative of Consultant prior to shipment.

The Cost of testing including the cost of traveling, boarding & lodging of the Client & Consultant representative to and from Pakistan to the factory and back shall be borne by the Contractor/Suppliers.

Before starting the performance test, manufacturer shall submit the test procedure and calculations to the consultant for approval. Testing parameters shall be verified by the Consultant and to be documented in a Factory Test Report.

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## 9. SPARE PARTS

9.1 Supplier shall furnish the essential spares parts for at least 2 years operation as recommended by the manufacturer and necessary tools.

9.2 The Fire Pump supplier shall furnish,

Operation and Maintenance Manual.

List of Spare parts of Diesel Engine, Pumps, Electric Motor, Controller, Motor Pump Control Equipment, etc.

## 10. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections:UL/FM

Listed
NFPA Approved
NFPA-20
NFPA-14
ASTM American Society of Testing & Materials
Equivalent to mentioned codes and standards may be approved by the Consultant on the provision of evidence of equivalent by the contractor.

FIRE HOSE DOUBLE VERTICAL CABINET Section- 74:02

## 1. SCOPE

Supplying, Installation, Rigging ,Lifting, Placement, testing, and commissioning of double vertical Fire Hose Cabinet, Valve, Hose and accessories as specified in schedule of equipment and as shown on drawings and specified herein & as per instruction of Consultant and local firefighting authorities.

## 2. TECHNICAL DESCRIPTION

2.1 The Fire hose double vertical cabinet shall be with Stainless Steel, dull finish front door and architrave, Back box Electro galvanized steel sheet, with Red electrostaticpowder coating.

### 2.2 UPPER COMPARTMENT

2.2.1 The upper compartment fits a hose reel, Swinging pipe type hose reel can be mounted on either side of the cabinet based on the site condition/riser access, consists basically of a steel drum or reel construction of mild steel, heavy duty discs, manual swing, finished in red polyester electrostatic powder coated with manual valve, PRV fit up to 30mtr hose tube length.

2.2.2 The hose tube swinging pipe type shall be, synthetic rubber covered with braided polyester cord reinforced synthetic tube confirming to BS-3169 and 5119 size 25mm( Dia:1‖), length 30Meter (100 Ft)

2.2.3 The nozzle shall be high density molded jet/spray/off nozzle chrome plated type size 1‖.

2.2.4 The valve shall be chrome plated size 1‖.

### 2.3 LOWER COMPARTMENT

2.3.1 The lower compartment fits one canvas lay flat fire hose rack 2.5‖, length 30 mtr, with landing valve, Nozzle and 2 Nos. portable fire extinguishers confirming to NFPA-14 for CLASS II.

2.3.2 The Fire hose rack confirming to FM standard class 2141, hose rack frame shall be Stainless Steel.304, with automatic release mechanism allows water to flow through the hose after removal of the hose and nozzle.

2.3.3 The hose shall be light in weight, with Thermoplastic lining with high tenacity filament polyester yarn in both the warp and weft direction to provide maximum strength to weight ratio, confirming to NFPA 1961/UL 219 with standard length 30 mtr (100 Ft).

2.3.4 The hose shall be resistant to chemicals and petrol product, The hose service pressure: 250 Psi, Burst pressure: 750 Psi.

2.3.5 The hose coupling shall be 2 ½‖ light Alloy Aluminium Female threaded brass coupling confirming to BS-336.

2.3.6 The Angle valve shall be, 2.5‖ with pressure regulator(Bronze) confirming BS-2060.

2.3.7 The diffuser shall be 2.5‖ Female NST Threaded, Discharge rate in full spray pattern: 130 US Gpm at 100 Psi .

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2.3.8 10 LBS Chemical Dry Powder Extinguisher and $CO^2$.

2.3.9 Door to be marked conspicuously ¯FIRE HOSE CABINET‖ and FIRE BRIGADE LANDING VALVE‖.

2.3.10 Cabinet shall be recessed type, constructed of 16-gauge sheet metal with angle ironreinforcement. Cabinet size shall be 1.6 mtr high, 0.8 mtr wide and 0.3 mtr deep.

2.3.11 The box shall be sufficient to provide ready access to equipment for immediate use when required, hose running freely from pivoting pin rack and valve turned on or off easily.

## 4. EXECUTION

4.1 All fire hose cabinets shall be securely mounted at locations shown on drawings. A steel support frame suitable for outdoor use shall be provided for free standing cabinets located on the roof. Stand shall be of steel construction with 2 coats of exterior enamel red in color mounting hardware and attachment shall be stainless steel.

4.2 In all hose outlets, UL listed adjustable pressure reducing valves shall be provided where required toreduce the flowing pressure to approximately 500kpa.

4.3 Provide in each hose cabinet a fire extinguisher as specified above. The pressure test on the extinguisher shall valid for 5 years.

4.4 At the top of each risers, provide a pressure gauge, complete with a valve, in the fire hosecabinet.

## 4. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections: ASTM. American Society of Testing & Materials.

National Fire Protection Agency NFPA-20

Equivalent to mentioned codes and standards may be approved by the Consultant on the provision of evidence of equivalent by the contractor.

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## BREECHING INLET WITH CABINET

Section- 74:03

### 1. SCOPE

Supply, installation, testing & commissioning of Breeching Inlet with Cabinet complete in all respect of, specified herein, & as per instruction of Consultant.

The dry riser shall be fitted with twin breeching inlet for fire brigade use in addition of firepumping station as per Pakistan fire Code.

### 2. DESCRIPTION

The breeching inlet shall comprises of 2 inlet, consisting of a 65mm instantaneous male coupling with 4‖ outlet, confirming BS 336: 1989 with a 25mm drain valve confirming BS 5154, PN 16 with non return valve and shall be protected by a cap secured by a suitable length of chain. The valve should be kept strapped and padlocked closed.

The breeching inlet are manufactured by confirming BS 5041 PART-3:1975 standard.

The breeching inlet and its fitting shall be suitable for working pressure of 10 bar and temperature range of 0 to 38 degC.

The body material shall be of Spheroidal Graphite iron confirming BS 1563 : 1997.
Inlet connection and non return valve material shall be of copper alloy confirming to BS12163: 1998.

The inlet connections shall be of non – return valve are of spring loaded mushroom type. The inlet shall be as Angus Fig-251 or equal and subject to approval by consultant.

The breeching inlet are red painted internally and externally.

### 3. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this sections:

ASTM. American Society of Testing & Materials.

National Fire Protection Agency NFPA

British Standards Institute.

Equivalent to mentioned codes and standards may be approved by the Consultant on the provision of evidence of equivalent by the contractor.

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PIPE WORK AND INSTALLATION Section- 74:04

## 1. SCOPE OF WORK

Supply, installation, testing and commissioning of pipes work with all and accessories for Mechanical Works confirming to latest guide-line of NFPA-14 for Standpipe, Private Hydrant and Hose System, complete in all respects as specified herein and as per drawings, and instructions of Consultant.

The layout of the pipe work shown on drawings are tentative and for tender purpose only. Final layout of the respective pipe work shall be prepared by the contractor in accordance with the equipment layout. The final layout as prepared by the contractor shall be submitted to the Consultant for approval and work shall be started on receiving approved drawings.

## 2. PIPE WORK INSTALLATION

2.1 The Engineer shall have the right to inspect any pipe, pipe joint, or pipe line fitting in orderto check quality of materials and workmanship or system operation. Any defect should be made good by the contractor at his own expense and to the satisfaction of the Consultant.

2.2 Standpipe system piping shall not be concealed in building walls or built in to pilaster:

2.3.1 Pipe used in stand pipe system shall be MS seamless Black Steel ASTM A53/A 53M Grooved, Welded and Seamless, Hot Dipped Zink-Coated confirming to ASTM A 153, grade B, Schedule-40.

2.3.2 Above Ground Piping & Pipe Fittings shall be Grooved Piping System shall be used and for Under Ground piping System shall be Welded with Wrought-Steel Fittings ASTM A 234/A 234M for Butt welding and Socket welding for above 50mm and smaller shall be threaded factory Gray Iron, galvanized confirming to class 250, ANSI B 16.4 and Malleable-Iron threaded fittings ASME B16.3, Class 150, stand pattern.

2.3.3 For above Ground Piping and fittings for piping larger than 50mm shall be joined. Factory galvanized mechanical roll grooved fittings and mechanical joints, gaskets, couplings and below 50mm shall threaded fittings and shall be UL Listed and FM approved.

2.4.3 Fittings for piping larger than 50mm shall be joined. Factory galvanized approved flanged, wrought steel gaskets, couplings shall be class 300, UL Listed and FM approved confirming to ANSI B16.9.

2.4.4 For a Under Ground Piping shall factory-applied protective Coating by three-layer of epoxy coating, adhesive, and heat-shrink PE Sleeve and wrap entire including all components with a minimum of 10mil. Polyethylene wrap overlapped 50% of the circumference and extended beyond ends of component as required for polyethylene to be secured to piping. The overlap seam shall be located to avoid backfill material from entering the encapsulated area.

2.5 Pipes should be spaced in ducts and below floors in a manner, which will permit access to any pipe for maintenance or removal without disturbing other pipes.

2.6 Pipe should not be solidly built into wall or finishes, and joints should not be formed in any un-accessible position.

2.7 Pipes should be fixed with a minimum clearance of 25mm between the surface of the pipe or insulation and finished surface of walls and a minimum 75mm from finished surface of floor at the lowest point and 50mm from the soffit of a ceiling.

2.7 Pipe shall be cut accurately to measurement established on the job site and worked into place without springing or forcing. All piping shall be installed with sufficient pitch to insure adequate drainage.

2.8 Each vent terminal shall be extended at least 1000mm or 3 ft. above the roof slab to minimize the possibilities of clogging and the return of foul air to the building.

2.9 Where different sizes of pipes, or pipes and fittings are to be connected, the proper size increase or reducers or reduced fittings shall be used between the two sizes.

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2.10 Any fitting or connection which has an enlargement, chamber, or recess with a ledge, shoulder, or reduction of pipe area that offers-an obstruction to flow through the drain is prohibited.

## 3. PIPE SUPPORTS AND HANGERS

3.1 All pipe work should be adequately supported on purpose made pipe supports to the satisfaction of the Consultant. Supports shall comply with, NFPA-13,B.S. 3974 whereas applicable. The supports should be selected for the particular duty, they are to perform and should be adequate for the loads and thrust imposed upon them and shall allow free longitudinal movement and expansion of the pipe work.

3.2 The anchors shall not impose forces on the structure in excess of that which the structure can withstand.

3.3 The Hangers rod supports and supporting devices and accessories shall be capable of supporting at least twice the live load of the product being supported.

3.4 All necessary "U" bolt or other guides should be provided to counteract side or vertical movement of pipe due to expansion. All supports should be graded to the required level of air elimination and drainage. Flexible supports should be used where vibration could be transmitted through the support. Pipe supports should not be attached to any piece of plant, equipment of other pipe.

3.5 Clevis hanger shall be adjustable of yoke and lower U strap design with cross bolt and manufactured by Hot Dipped Galvanized steel. Cross bolt shall have a double locking nut. Vertical adjustable supporting rod shall have load nut below the yoke and a locking nut above the yoke. Vertical inserts installed using power activated gun will not be accepted. C type beam clamp will not be accepted.

3.6 Concrete inserts shall be factory made Hot Dipped Galvanized Malleable Iron, poured in place type, screwed or toggle style.

3.7 Pipe fixing and supports should be arranged at intervals not greater than the distances as indicated on drawings.

3.8 The contractor should be responsible for the position and alignment of all built in brackets and support before concreting commences and for ensuring, that the positions are maintained until the concrete has hardened.

3.9 Concrete anchors shall be factory made cadmium plated Malleable Iron or Alloy Steel expansion shield type.

3.10 All vertical pipes shall be supported so as to prevent sagging and swinging.

3.11 Riser clamp shall be Hot Dipped Galvanized Steel band shaped to tightly fit O.D of pipe, secured with bolts.

3.12 Pipes at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment, valves and control valves. Piping shall be supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

3.13 All channels, angles, plates, clamps etc necessary for the fastening hangers shall be furnished and fitted by the Contractor. All hangers shall be properly sized for the pipe to be supported. Oversized hangers shall not be permitted, without Consultant approval.

3.14 Details of hangers and supports to be used by the Contractor shall be submitted to the Engineer for approval before fitting. All hangers shall be provided with lock nuts and have provision for vertical adjustment of pipes.

3.15 Parallel groups of pipes shall be supported by trapeze type hangers of steel construction.

3.16 Individual horizontal piping shall be supported by hangers consisting of malleable split rings with malleable iron sockets, or steel clevis type hangers, or roller hangers as directed by the Consultant.

3.17 Vertical piping shall have heavy wrought iron or steel clamps securely bolted on the piping with the end extensions bearing on the structure of the building.

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3.18 Piping shall be anchored where required to localize expansion to prevent undue strain on piping and branches. Anchors shall be entirely separate from hangers and shall be heavy forged or welded construction of approved design.

## 4. MASKING PLATES

4.1 Where pipes pass through walls, floors or ceiling, the hole should be closed with G.I. Sheet metal masking plates fitted around the pipes and over the sleeves. Where necessary, the plates should be shaped to suit the building structure. Pipe should be spaced to allow standard split plates to be fixed without cutting.

4.2 Wherever possible and where this involves special fittings or settings of pipes, even though not shown on the drawings, such fittings should be provided by the contractor at no extra cost.

## 5. PIPE SLEEVES

5.1 Sleeves should be fitted to pipes at all points where the pipes pass through walls, floors and ceilings and the contractor should be responsible for the accuracy, correct alignment and levels of all holes required to be left or cut for the fitting of sleeves.

5.2 All sleeves required to be built into or embedded in the structural concrete should be placed in position by the contractor before the concrete is placed. The contractor should ensure that the sleeves remain in the correct position while concreting takes place and until the concrete has hardened.

5.3 Sleeves for copper pipe work, should be either copper or plastic and for mild steel, or plastic.

5.4 The weight of pipes should not be born by sleeves, and all pipes must be set concentric with their sleeves with a suitable clearance all around to allow free movement of pipes under all conditions of operation. All sleeves through walls should finished flush with the finished surface of the wall.

5.5 Sleeves passing through external wall, water proof membranes and roofs should be made water tight using a suitable flashing and water proof compound, all integrated into the building structure and to the approval of the Consultant.

## 6. WATER FLOW ALARM

6.1 Automatic Flow Alarm Switch shall be UL Listed and FM approved for the size of pipe inwhich will installed as a paddle type water flow indicator in wet stand-pipe system.

6.2 Water Flow Alarm shall utilize a sensing mechanism to the type of standpipe.

## 7. PRESSURE GAUGES

7.1 All pressure gauges shall be UL Listed and FM approved with 3 1/2‖ (89-mm), connected to each discharge pipe from the Fire Pump at the top of each stand pipe.

7.2 Each gauge shall be controlled by a valve having an arrangement of drain.

7.3 Gauges shall be installed on the suction and discharge side of all pumps, on incoming water service and highest point of risers.

7.4 A valved outlet for a pressure gauge shall be installed on the upstream side of every pressure-regulating valve.

## 8. PROTECTION AND PAINTING

Open ends lefts before or during the progress of the works should be protected by the use of purpose made iron or plastic caps, and plugs. Wood, paper, rage or other such materials should not be used. All pipe work should be stored in purpose made pipe racks above the ground and ends shall be protected by plugs or caps.

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## 9. STEEL WORK FOR PIPE SUPPORTS

All steel work used for the fabrication of hangers, pipe supports brackets and anchors, should be hot dip galvanized as per BS 729 after fabrication before fixing. The exposed to weather steel work should be further protected by applying one coat of zinc primer before installation following the two coats of corrosion resistant paint after installation.

## 10. PIPE WORK MOVEMENT

Wherever possible provision for movement of pipe work due to expansion and contraction should be made by changes of direction. Where this is not possible adequate expansion loops and expansion joint should be provided as necessary.

Connections to branch mains should be made in such a manner as to avoid under stress being forced upon them due to expansion and branches should be pre-stressed by cold spring during erection.

Expansion loops should be shop manufactured and annealed after welding and each leg of the loop should be pulled or compressed cold to approximately 50% of the estimated expansion or contraction on each leg.

All expansion below should be of the axial or angular compensated type with end connections to suit the pipe work to which it is connected.

Unless otherwise specified all pipe work should be adequately guided both upstream and downstream of any expansion compensating device or anchor. All expansion devices should be installed such that no damage to the structure result from their action.

Where pipe work crosses expansion joints in the building a flexible joint shall be provided to take account of both movement of the pipe work and of the building structure. Axial compensators should not be used on suspended pipe work.

## 11. PIPE WORK JOINTING

### a. THREADED JOINTS

The threads of all pipes shall be effectively covered with a good quality grease or other suitable compound, and each pipe be above 50 mm (approx.:2") nominal bore shall have a protecting ring affixed to the un-socketed screwed end.

Unions and flanges should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flanges being connected should be alike in all cases. Unions and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank.

### b. WELDING

b.1 Unless otherwise noted on the drawings, welding shall be done in accordance with latest edition of BS 4515.

b.2 All welders employed on pipeline fabrication must be qualified in accordance with BS 4515. Unless otherwise stated on drawings, all joints on piping 50 mm and larger shall be butt welded type.

b.3 Prior to start of welding work on pipelines, a detailed procedure specification shall be established and qualified to demonstrate that welds having suitable mechanical properties (such as strength, ductility and hardness ) and soundness can be made by this procedure. This procedure shall be submitted to Consultant for approval.

b.4 Before being welded, all surfaces must be clean and free from rust, paint, oil, scale or other detrimental matter.

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b.5 Pipe shall be properly supported and aligned by jigs, or clamps as required in order to preclude extraneous load and minimize strains during tackling. Small tack welds penetrating to the bottom of the groove may be used in fitting up.

b.6 Small tack welds used for fit-up, if free from cracks may be included in the first pass provided they have been made up by a qualified welder to the same procedure as that required for the first pass. Defective tack welds shall be clipped out before laying the firs pass.

b.7 After preparation and fit-up, weld joints shall be made by qualified welders as per approved procedure.

b.8 All welding shall be supervised and records maintained to ensure that each weld can be subsequently identified with the individual welder concerned.

b.9 Electrodes shall be kept clean and dry and stored in a heated place. The issue of electrodes shall be supervised to ensure the use of correct electrodes and the rotational consumption of stocks. Electrodes shall be dried according to manufacturer's recommendations.

b.10 Sections of pipe shall not be welded together for lengths below 3 meters and the number of welds shall be kept to a minimum for longer lengths.

b.11 For all fabrication, the complete circumference of the first five welds of each welder shall be radio graphed. The radiographs shall be retained for examination and approval by the Engineer. Minor defects in welds may be repaired provided complete records are kept and passed to the Consultant when he inspects the finished work. Major defects which might indicate incorrect choice of materials or unsuitable welding procedure shall be reported back to the Consultant in writing for a decision.

b.12 Defects in welds requiring repair shall be removed by flame or arc gouging followed by grinding and dressing.

b.13 Projections of weld metal into the pipe bore at welded butt joints shall not exceed 1.5 mm. Excessive projections on accessible joints should be removed. Welds attaching welding neck orifice flanges to pipe should be ground smooth on the inside.

b.14 Imperfections such as cracks, incomplete penetration, weld under-cutting and reinforcement shall be examined visually and made good wherever necessary.

b.15 In addition to tolerances contained within the specified codes or standards, the following also applies.

b.16 All linear dimensions involved in the relative position of branches, bosses, flanged ends, flow instrument tapings and changes in direction each to each other shall be maintained within ± 3 mm.

b.17 All angular dimensions of bends and branches shall be maintained within± 1/4°.

b.18 Alignment of flanges and branch welding ends measured across any diameter shall not deviate more than 3.5 mm/m of diameter.

## 12. TESTING

The Contractor shall pressure test all Fire protection piping included in the Contract. Test shall be made according to NFPA Standard.

The Consultant shall be notified one week in advance of any testing so that test can bewitnessed.

Defect that develop during the test shall be promptly remedied and testing shall be reapplied to the satisfaction of the consultant.

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## 13. RELEVANT CODES & STANDARD

Following are relevant standards and codes are applicable to this section.

| | |
|---|---|
| NFPA-14 | Installation of Stand Pipe, Private Hydrant and Hose SystemBS 21 Pipe threads |
| BS 534 | Steel pipes fitting and specialsBS |
| 1387 | Steel tubes |
| BS 1710 | Pipe identification |
| BS 3974 | Pipe hanger & supports |
| BS 4505 | Flanges |
| BS 794 | Hot dip galvanized coating CP |
| 2010 | Insulation of pipe line in land |

Equivalent to mentioned codes standards may be approved be the Consultant on theprovision of evidence of equivalent by the contractor.

VALVES AND ACCESSORIES Section- 74:06

## 1. GENERAL

Supply, Installation of valves and other pipe work accessories as indicated on drawings, specified herein and as per instruction of Consultant.

## 2. VALVE DESCRIPTION

Unless otherwise specified, valves should be UL Listed and FM approved of the same nominal size as the size of the pipe line to which they are connected. All valves that incorporated packed glands should be capable of having glands packed when connected in line and subject to the working line pressure.

All isolating valves shall provide tight shutoff in the closed position and be suitable for anticipated pressure or a minimum of 175 psi working pressure.

All valves on connections to water supply to sprinklers shall be UL listed butterfly type indicating valves except for the following which shall be O.S.& Y

1. All indicating valves on the supply side of the backflow preventer;
2. The indicating valve immediately adjacent to the backflow preventer on the system side.
3. All indicating valves on the suction side of a fire pump.

All hand wheel valves shall rotate clockwise to close the valve. Check valve should be install in a plane only, which is recommended by the manufacturer and approved by the Consultant.

Valve bonnets and covers should be easily removable and the gasket and glands should be readily renewable.

All gate and sluice valves shall incorporate guides in the body to ensure the correct position of valve discs at all times. The working parts of valves and cock should be bronze and the body casting should be bronze for valves and cocks up to 50 mm. connection and cast iron for valves and cock of 65 mm. diameter connection and above.

Gland rings and spindles should be of a good running fit and stuffing boxes should be fitted with neoprene 'O' ring seals. The exterior finish of all bronze valves bodies should be polished except otherwise specified.

Check valves up to and including 65 mm. diameter should be of 'Y' pattern swing type having regrindable bronze discs with the disc seat integral with the valve body. The disc and seat should be accessible via a screwed cap for regrinding without removal of the disc.

Isolating valves for all water piping should be full way type gate valves unless otherwise indicated and should be fitted in the following positions, whether shown on drawings or not:

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- Inlet and outlet connections to pumps.
- Inlet and outlet connections to water strainers and filters
- Inlet and outlet connections to tanks.
- Inlet and outlet connections to three Port Valves.
- By pass connection around valves and equipment.
- Branch connection from service mains.
- At top or base of the riser served from below or above.

## 3. ACCEPTABLE STANDARD FOR VALVES AND COCKS

The following valves should be those used for all systems, unless otherwise specified.

**3.1** Valves: Stand Pipe System and Sprinkler System

a. Gate Valves,50mm (Dia :2") and Smaller**: UL listed and FM approved** 175 Lb,(WWP) non-shock, Bronze body, threaded ends, OS&Y rising stem, bronze yoke, solid wedge, repack able when wide open. MSS SP-80, Class 225, ASTM B62.Cast bronze composition.

b. Gate Valves,50mm (Dia :2") and Smaller**: UL listed and FM approved** 300 Lb,(WWP) non-shock, Bronze body, threaded ends, integral seats, Nitrile rubber disk, bronze stem and locknut. MSS SP-80, Class 500, ASTM B62.Cast bronze composition.

c. Gate Valves, 65mm (Dia :2-1/2") and Larger: outside screw and yoke(OSY), **UL listed and FM approved** shall be malleable-iron/cast iron as specified MSS SP-70, class 175 iron body, bronze mounted, solid wedge, ASTM A126, Class B cast iron, flanged ends with.

d. Butterfly Valves**:** 175 psi tight shut-off, ASTMA126: **UL listed and FM approved** Sprinkler System and Stand piping isolation and other approved ground controlling valves shall be gear-operated slow-close butterfly valves with flag type indicator and two internalsingle-pole, double-throw monitor switches.

1) Body: Wafer type, ductile iron, grooved body.
2) Disc: electroless-nickle coated
3) Stem: Solid one-piece, 304 or 316 or 410 stainless steel with bronze busing.
4) Seat and "O" Rings: EPDM pressure responsive seat.
5) Upper and Lower Stem Bearings: Bronze or reinforced Teflon.

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e. Supervised Valves: 40mm (Dia:1-1/2") and Smaller**: UL listed and FM approved** Sprinkler controlling valves 1 ½ inches and smaller shall be of Class 225, slow-close supervised butterfly valve. Valves controlling fire sprinklers in elevator pits shall be unsupervised.

f. Drain valves**:** Drain valves need only be **UL Listed & FM approved** screw-in bonnet bronze globe valves, rated to 175 psi non-shock cold water working pressure from approved equal. Low point drain valves shall have, in addition, a 3/4 inch brass nipple with 3/4 inch mail hose threads and cap.

i. Plug Valves, 50mm (Dia:2") and Smaller**:** lubricated plug type, 200 lb. **UL Listed & FM approved** water operating gage pressure iron body and plug, regular pattern, threaded, with indicating arc; Equal by Walworth, Homestead, or WKM.

j. Plug Valve, 65mm (Dia:2-1/2") and Larger**:** lubricated plug type, 200 lb. **UL Listed & FMapproved** water operating gage. Iron body and plug, regular pattern, flanged, with indicating arc. Equal by Walworth, Homestead, or WKM.

k. Check Valves,50mm (Dia: 2") and Smaller**:** MSS SP80, shall be of Class 225, **UL Listed& FM approved** threaded ends, body and caps shall be of ASTM B62 cast bronze composition, swing type disc.

l. Check Valves, 65mm (Dia: 2-1/2") and Larger**:** Mss SP71 shall be iron body grooved, class 225 **UL Listed & FM approved** bronze seat, elastomer coated ductile iron or stainless steel clapper with a replaceable rubber seal and minimum pressure of 175 Psi non-shock cold water working pressure. Conforming to ASTM A126, Class B.

m. Non-Slam-Check Valves (Pump Discharge)**: UL listed and FM approved** with semi-steel body, bronze trim, top and bottom center guide, stainless steel spring and 150lb. flangedends.

n. Stand Valve FM Floor**: UL listed & FM approved** 175 Lb.(WWP) high strength alloy iron body and bonnet, non-rising stem, bronze alloy stem and seat ring, bronze bushing, sold taper wedge, mechanical joint, 2‖ square operating nul.

o. Stand Pipe Valve**: UL listed & FM approved** 65mm (Dia:2-1/2) cast brass single hydrant gate valve, 300Lb. wheel handle, outlet end with threads, cap and chain,(rough, polished brass, rough, polished chrome plated)

p. Air Vents: manual type, of size for proper venting. Install at high points of systems.

q. Backflow prevention assemblies: Provide a double check valve assembly.

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## THROUGH-PENETRATION FIRE STOPPING FOR MEP WORKS

Section-74:07

### 1. GENERAL

Drawings and general provision of Contracts, Including General and SupplementaryConditions, Specification Section, apply to work specified in this section.

### 2. DEFINITIONS

Fire stopping: Material or combination of materials used to retain integrity of fire- construction by maintaining an effective barrier against the spread of flame, smoke and hot gases through penetrations in fire rated wall and floor assemblies.

### 3. GENERAL DESCRIPTION OF THE WORK OF THIS SECTION

Only tested fire-stop system shall be used in specific locations as follows:

3.1 Penetration for the passage of Duct, Pipe and other mechanical equipment through fire-ratedvertical barriers (walls and partitions) horizontal barriers (floor, ceiling assemblies) vertical services shaft wall and penetrations.

3.2 Repetitive plumbing penetration in fire-rated floor assemblies, Penetrations exit for the installation of tubs, showers, aerators and other plumbing fixtures.

3.3 Penetration for the passage of cables, conduit and other electrical equipment through fire- rated vertical barriers (wall and partitions), horizontal barriers (floor, ceiling assemblies) vertical services shaft wall and penetrations.

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SPRINKLER HEADS Section-74:08

## 1. GENERAL

Supply & installation of Sprinkler shall be of Sprinklers shall be **UL listed or FM approved**. Any sprinkler that incurs damage, is painted, or is sprayed with any obstructive material shall be replaced at no cost to the Owner.

Installation of sprinklers shall be coordinated with other work including duct and electric fixture installation to prevent sprinkler obstructions.

Sprinklers that may be subject to mechanical damage shall be provided with guards listedby UL and IRI approved for the model of sprinkler used.

Quick response sprinklers are required throughout all light hazard occupancies andencouraged throughout ordinary hazard occupancies.

## 2. TECHNICAL DESCRIPTION

The glass bulb sprinkler heads should be of the pendant type and rated ¯**Green‖** for 80°C, ¯**Blue‖** for 107°C They shall be arranged such that there is not interference with the discharge pattern and they shall be positioned between 75 and 150 mm below ceilings.

The sprinklers and pipelines shall not be spaced too close together in order to prevent an operating sprinkler from wetting, and thereby delaying the operation of, adjacent sprinklers.

In locations where sprinkler heads are liable to be operated or damaged by accidental blow, they should be protected by stout metal guards. Care shall be taken to ensure that thenormal operation of the sprinkler head in the event of a fire is not impeded by such guards.

Sprinklers in false ceilings areas shall be the concealed or recessed type. They shall be the two-piece design with closure and mounting plate which allows for easy installation and removal.

Sprinklers in parking and hardware areas shall be the pendant or upright bulb type with a12mm diameter orifice and temperature rated to 80°C with a natural brass finishes and sprinkler guard.

### 2.1 Sprinkler System Alarm Devices

The system shall be provided with alarm devices.

### 2.2 Alarm Valve

Alarm valves shall be **UL listed and FM approved**. They shall be check type, with a rubber faced clapper, designed for use in wet pipe systems for automatic actuation. The alarm valve may be installed vertically or horizontally with inlet and outlet connection in accordance with the relevant provisions of ANSI B 16.1.

## 2.3 Basic Trip and Retarding Chamber

Basic trip and retarding chamber shall be **UL listed and FM approved**. It shall be used In order to prevent any false alarm that may be caused by small variation in pressure.

The chamber should consist of a by-pass check valve to permit slow as well as small transient increases in water supply pressure to be passed through to the system and held at their highest value, without opening of the water way clapper.

## 2.4 Pressure Alarm Switches

Pressure alarm switches shall be **UL listed and FM approved**. They shall be designed to indicate a water discharge from automatic sprinkler and the start-up or shut down of auxiliary fire protection system equipment. The one single pole double throw snap-action switch‘s components shall be enclosed in an oil resistant NEMA Type 2 drip proof indoor rated casing. water discharge from automatic sprinkler and the start-up or shut down of auxiliary fire protection system equipment

## 2.5 Stop Water Motor Alarms

Water motor alarms shall be **UL listed and FM approved.** They shall be hydraulically operated outdoor alarms, designed for use with fire protection system water flow detection devices. They shall be suitable for mounting to any type of rigidwall and to consist of an approved ¯Y‖ strainer for use in the alarm line utilizing ahigh energy efficient, light weight, impeller design which can produce a very high sound pressure level. The gong, gong mount, and water motor casing shall bemade with corrosion resistant aluminium alloy. The drive shall be of the type thatdoes not require lubrication.

## 2.6 Zone Valve

Zoning valves shall be UL listed and FM approved. They shall be gear operated butterfly valves with internal or external monitor switch. They shall have a wafer or lug style body for mounting between ANSI 125/150 flanges. They shall be rated for a 12 bar operating pressure and have a cast iron body and an EPDM seat with bronze disc.

## 2.7 Water Flow Detectors

Water flow detectors shall be **UL listed and FM approved** and shall be designedfor use with wet pipe, automatic sprinkler systems. They shall utilize a vane type sensor to actuate two single pole double throw snap-action switches when water flows at a sustained rate of 17.5 liters or more. They shall be used where sectional water flow signals are required.

## 2.8 Drain and Test Orifice

The system shall incorporate a 25 mm drain and a 15 mm test orifice for flow control inspection testing and drainage of feed mains.

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**FIRE SUPPRESSION SYSTEM &**
**CLEAN AGENT RELEASING PANEL** **Section- 74:09**

## PART-1 GENERAL

### 1. SCOPE OF WORK

1.1 Design, Supply & Installation of an engineered fire detection system, total flooding, clean agent, fire suppression system, storage tanks, nozzles, control panel, wiring, annunciators, alarm and other equipments and shall be capable of being interfaced with the BMS through RS 232, necessary for a complete operational system.

1.2 The contractor shall submit drawings indicating the general arrangements of the areas to receive detection and protection. Contractor check all area, drawings so that all items affecting the operation of the fire detection/fire suppression system are considered in the design of the engineered.

1.3 All the system shall be installed by an authorized of distributor certified for the design, installation and service of the fire suppression system.

1.4 The contractor/fire protection engineered solution provider, provide 24-hour emergency service,7 days a week and shall be able to respond to an emergency situation with in 2hours of receiving an emergency trouble call.

1.5 The contractor shall maintain a minimum amount Rs---------- liability insurance.

### 2. REQUIREMENT

2.1 The installation shall be made in strict accordance with the drawing, specification and applicable Standards. All equipment, devices and materials shall be listed by the standardizing agencies (UL and/or FM)

2.2 Design and installation of the fire detection/fire suppression system will be in accordance with the following guidelines and regulatory agencies.

2.2.1 NFPA 2001 Standard on Clean Agent Fire Extinguishing System
2.2.2 NFPA 72 National Fire Alarm and Signaling Code, Latest Edition
2.2.3 NFPA 70 National Electrical code, Latest Edition
2.2.4 Americans with Disabilities Act, Title 24, Latest Edition

### 3. TECHNICAL SUBMITTAL

3.1 The following shall be submitted for approval after award of works and prior to delivery ofequipment, devices and materials.

3.2 Material and equipment information shall include original manufacturers catalog cut sheet and technical data for each component or devices used in the system. This shall not include, but not be limited to, the following;

3.2.1 Detectors
3.2.2 Manual discharge switch
3.2.3 Control Panel
3.2.4 Release devices
3.2.5 Alarm Devices

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3.2.6 Agent Storage Cylinders
3.2.7 Mounting brackets
3.2.8 Discharge Nozzles
3.2.9 Abort Stations
3.2.10 Piping Isometrics
3.2.11 Flow calculations

3.3 Provide information outlining the warranty of each component or device used in the system.

3.4 Provide information outlining the operation and maintenance procedures that will berequired of the owner. This information shall explain any special knowledge or tools the owner will be required to employ and all spare parts that should be readily available.

3.5 Drawings shall indicate locations, installation details and operation details of all equipment associated with the fire suppression system. Floor plans shall be provided showing equipment locations, piping, point-to-point wiring and other details as required. Floor plans shall be drawn to a scale of not less than 1/8 in. (3.2 mm) = 1 ft-0 in. (0.3 m). Elevations, cross sections and other details shall be drawn to a larger scale as required. Isometric piping layouts shall be provided with the shop drawings. In addition, point-to- point electrical layout drawings shall be provided.

3.6 Show a complete Riser diagram with specific detail on connections to all monitor and control functions.

3.7 Testing plan that includes means, methods and schedules for interface testing with systems that will be interfaced to via monitor or control modules.

3.8 Sequence of operation, electrical schematics and connection diagrams shall be provided to completely describe the operation of the fire suppression system controls.

3.9 Flow Calculations shall be provided.

## PART-2 TECHNICAL

### 4.0 SYSTEM DESCRIPTION AND OPERATION

4.1 The equipment manufacturer shall be from approved make.

4.2 The system shall be a total flooding clean agent, fire suppression system designed to provide a uniform concentration of agent for the protected area:

4.2.1 The amount of clean agent to be provided shall be the amount required to obtain a uniform (minimum) concentration as required by the design manual for the time period specified. Take into consideration such factors as non-closable openings (if any), "rundown" time of fans, time required for dampers to close (and requirements for any additional dampers), and any other feature of the facility that could affect concentration. The design concentration shall be by volume at 70 °F (21 °C).

4.3 Smoke Detection: The fire protection system shall be automatically actuated by either counting zone detection or cross-zoned detection methodology. Smoke sensors / detectors shall utilize photoelectric technology and/or Aspiration Smoke Detectors (ASD) for very early warning smoke detection. Smoke detectors and ASD sample points shall be installed at no more than 250 $ft^2$ (23.2 $m^2$) of coverage per detector. When using analog addressable sensors or ASD detectors offering pre-alarm thresholds, further system design consideration is suggested for providing very early warning detection which can offer extended investigationtime prior to suppression agent release. In all cases, the compatibility listings of the detectors for use with the control unit should be observed. The system shall require two detectors in alarm prior to automatic agent release.

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Both Photoelectric and ASD type smoke detectors can be combined in the releasing process,using one of following methods:

4.3.1 1st alarm ASD / 2nd alarm ASD

4.3.2 1st alarm ASD / 2nd alarm Photoelectric Detector

4.3.3 1st alarm Photoelectric Detector / 2nd alarm Photoelectric Detector

## 5.0 AUXILIARY COMPONENTS

5.1 Double action manual releasing stations shall be provided at each exit of the protected areaand shall, when activated, immediately release the clean agent and cause all audible/visual alarms to activate. In addition, activation of the manual releasing stations shall cause immediate shutdown of air and power circuits.

5.2 Abort stations shall be provided at each exit of the protected area and shall, when operated interrupt the discharge of clean agent and emergency power-off functions. The abort stations shall be momentary devices (dead-man) requiring constant pressure to maintain contact closure.

**Note**: Manual Releasing Station activation shall override any abort station. Abort stationoperation shall be per IRI and FM guidelines.

## 6.0 SEQUENCE OF OPERATION

**6.1** Activation of any single smoke detector in any detection zone shall:

6.1.1 Cause a first-stage alarm.

6.1.2 Energize a lamp on the activated detector and identify detector on thedisplay of the control panel (and remote annunciator, if included).

**Note**: The shutdown of electrical equipment will be optional based on requirements of thelocal AHJ or applicable standards.

**6.2** Activation of a second smoke detector shall:

6.2.1 Transmit an alarm signal to remote monitoring or building alarm panel.

6.2.2 Cause a second-stage (pre-discharge) Audio/Visual alarm to operate.

6.2.3 Operate auxiliary contacts for air conditioning shutdowns and automatic dampers.

6.2.4 Initiate a programmable time delay (Clean agent release).

**6.3** Upon completion of the time delay the fire suppression system shall:

6.3.1 Cause a discharge alarm to be activated.

6.3.2 Operate auxiliary contacts for emergency power off of all electrical equipment (excluding lighting and emergency circuits for life safety).

6.3.3 Activate visual alarms (strobe) at protected area entrance.

6.3.4 Energize control solenoid for clean agent cylinders releasing gaseous agentinto the protected area.

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PART-3 Equipment, Component & Materials

All equipment, component and material shall be of single manufacturer.

The name of manufacturer, model no and serial no shall appear on all major equipment & components

## 7.0 ELECTRICAL

7.1 All electrical enclosures, raceways and conduits shall be employed in accordance withapplicable codes and intended use and contain only those electrical circuits associatedwith the fire detection and control system and shall not contain any circuit that is unrelated to the system.

7.2 Unless specifically provided otherwise in each case, all conductors shall be enclosed in steel conduit, rigid or thin wall as conditions dictate.

7.3 Any conduit or raceway exposed to weather or other similar conditions shall be properly sealed and installed to prevent damage. Provisions for draining and/or drying shall be employed.

7.4 NEMA rating and/or electrically hazardous classifications shall be observed and any equipment or materials installed must meet or exceed the requirements of service.

7.5 Any wiring shall be of the proper size to conduct the circuit current but shall not be smaller than #18 AWG unless otherwise specified for a given purpose. Wire that has scrapes, nicks, gouges or crushed insulation shall not be used. The use of aluminum wire is strictly prohibited.

7.6 Splicing of circuits shall be kept to a minimum and are only to be found in an electrical device suited for the purpose.

7.7 Wire spliced together shall have the same color insulation.

7.8 Wire splices shall be made with appropriate devices suited for the purpose.

7.9 All wire terminations shall be made with crimp terminals unless the device at the termination is designed for bare wire terminations.

7.10 All electrical circuits shall be numerically tagged with suitable devices at theterminating point and/or splice. All circuit numbers shall correspond with theinstallation drawings.

7.11 The use of colored wires is encouraged but not required unless dictated by state or localauthorities.

7.12 White-colored wire shall be used exclusively for the identification of the neutral conductor of an alternating current circuit.

7.13 Green-colored wire shall be used exclusively for the identification of the earth groundconductor of an AC or DC circuit.

## 8.0 AUTOMATIC CONTROL SYSTEM

8.1 All control systems shall be UL Listed and FM approved and be utilized with listed or approved compatible operating devices and shall be capable of the following features:

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8.1.1 Ground fault indication

8.1.2 Supervised detection circuit(s)

8.1.3 Supervised alarm circuit(s)

8.1.4 Supervised release circuit(s)

8.1.5 Supervised manual pull circuit (if applicable)

8.1.6 Supervised primary power circuit

8.1.7 Battery standby

8.1.8 4.3‖ color touch screen LCD operator interface and LED indicating lamps

8.1.9 Key lock steel enclosure

8.1.10 Programmable time delay

8.1.11 Programmable detection logic

8.1.12 Microprocessor based logic

8.1.13 History buffer

## 9.0 CONTROL PANEL (AGENT RELEASING CONTROL PANEL)

**9.1** The Fire Alarm Control Panel (FACP) shall be an control panel with the capability of protecting up to 20 hazards. The panel shall contain a Central Processing Unit (CPU) with integral 8 amp power supply which is rated to provide 8 amp for ¯Special Application‖ appliances including suppression release peripherals such as horns, strobes and horn/strobes and rated to 6 amp for ¯regulated 24 VDC‖ appliance power. The CPU shall communicate with and control the following types of equipment used to make up the system: addressable and conventional initiating devices, addressable modules, annunciators, and other system controlled devices.

**9.2** System Capacity and General Operation:

9.2.1 The control panel shall provide up to a 250 addressable point capacity with the capability of expansion to 3 loops.

9.2.2 The system shall include 4 Class B programmable notification appliance circuits rated at 3 A each.

9.2.3 The control panel and remote annunciator (optional) shall include a full featured, intuitive color touch screen display capable of supporting up to two languages. The menu-driven interface shall provide color coded system status LEDs, allow for direct control of the fire alarm system and also allow for quick access to more detailed system information.

9.2.4 The control panel shall provide the following features:

9.2.4.1 Drift Compensation to extend detector accuracy over life.

9.2.4.2 Sensitivity Test meeting requirements of NFPA 72.

9.2.4.3 Maintenance Alert to warn of excessive smoke detector dirt or dust accumulation.

9.2.4.4 System Status Reports to display, export to USB device (or print if optional RS232 module is provided).

9.2.4.5 Rapid manual station reporting (under 2 seconds).

9.2.4.6 Non-Alarm points for general (non-fire) control.

9.2.4.7 Periodic Detector Test conducted automatically by software.

9.2.4.8 Pre-alarm for advanced fire warning.

9.2.4.9 Counting/Cross Zoning with the capability of: counting 2 detectors in alarm, 2 software zones in alarm, or 1 smoke detector and 1 thermal detector in alarm.

9.2.4.10 March time and temporal coding options.

9.2.4.11 Walk Test

9.2.4.12 Check for 2 detectors set to same address.

9.2.4.13 The real time clock may also be used to control non-fire functions at programmed time-of-day, day-of-week, and day-of-year.

9.2.4.14 Day/Night automatic adjustment of detector sensitivity.

9.2.4.15 Device Blink Control for sleeping areas.

9.2.4.16 Discrete status LEDs for Alarm, Priority 2, Supervisory, Trouble, Alarm Silenced and AC power indications plus three additional programmable LEDs with associated control switches with provisions for custom labels.

**9.3** The control panel shall be capable of coding Notification circuits in Slow March Time (20 BPM), Fast March Time (120 BPM) and Temporal Code (NFPA 72).

9.3 Central Microprocessor:

9.3.1 The microprocessor unit shall communicate with, monitor, and control all external interfaces with the control panel. It shall include system program storage in non- volatile memory for building-specific program storage, and a "watch dog" timer circuit to detect and report microprocessor failure.

9.3.2 The microprocessor unit shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Such control- by-event programs shall be held in non-volatile programmable memory and shall not be lost even if system primary and secondary power failure occurs.

9.3.3 The microprocessor unit shall also provide a real-time clock for time annotationof system displays and history file.

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9.4 Display:

9.4.1 The touch screen display shall provide all the controls and indicators used by the system operator.

9.4.2 The display shall include status information and custom alphanumeric labels for all addressable and conventional detectors, addressablemodules, and software zones.

9.4.3 The display shall by a 4.3 inch color touch screen display.

9.5 Signaling Line Circuit (SLC):

9.5.1 The SLC interface called an IDNet+ circuit, shall provide power to and communicate with up to 250 addressable points which can include Ionization, Photoelectric, or Thermal detectors along with all monitoring and control points. This can be accomplished over one to three SLC loops and shall be capable of NFPA 72 Class A or B wiring.

9.5.2 The loop interface board(s) shall receive and process information from all detectors to determine whether normal, alarm, supervisory or trouble conditions exist for each detector. The software shall automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The information shall also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

9.5.3 The detector software shall meet NFPA 72, requirements and be certified by UL as a calibrated sensitivity test instrument.

9.5.4 The detector software shall allow manual or automatic sensitivity adjustment.

9.6 Enclosures:

9.6.1 The control panel shall be housed in a UL listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust- resistant prime coat, and manufacturer's standard finish.

9.6.2 The door shall provide a key lock and include a glass or other transparentopening for viewing of all indicators.

9.7 All interfaces and associated equipment are to be protected so they will not be affected by voltage surges or line transients consistent with UL standard 864.

9.8 Optional modules shall be available for NFPA 72 supervising station and public emergency alarm reporting systems. The control panel shall have the ability to meet the latest requirements of UL 864 for delayed AC fail reporting.

9.9 Power Supply:

9.9.1 The power supply shall operate on 120 or 240 VAC, 50/60 Hz, and shall provide all necessary power for the control panel. The power supply shall have a 6 A output rating which provides current for special application devices, IDNet devices, module currents and auxiliary output currents. When NACs are controlling regulated 24 DC appliances, total NAC current available shall be 3 A.

9.9.2 It shall provide a battery charger for 24 hours of standby using dual-rate charging techniques for fast battery recharge.

9.9.3 It shall provide an earth detection circuit capable of detecting earth faults onI/O modules field wired circuits connected to power supply.

9.9.4 It shall be power-limited using Positive Temperature Coefficient (PTC) resistors andsolid state circuits.

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9.10 Field Wiring Terminal Blocks:

9.10.1 For ease of service, all panel I/O wiring terminal blocks shall have sufficientcapacity for 18 to 12 AWG wire.

9.11 Field Programming:

9.11.1 All programming shall be accomplished through a standard PC laptop.

9.11.2 All field defined programs shall be stored in non-volatile memory.

9.11.3 The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Three levels of password protection shall be provided in addition to a key-lock cabinet. One level is usedfor status level changes such as zone disable or manual on/off commands. A third level (higher-level) is used for actual change of program information.

9.11.4 A special program check function shall be provided to detect common operatorerrors.

9.11.5 For flexibility, an off-line programming function with batch upload/download shallalso be available.

9.12 Specific System Operations:

9.12.1 Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent smoke detectors in the system from the system keypad. Sensitivity range shall be within the allowed UL window.

9.12.2 Alarm Verification: Verification is implemented using zones with 512 zones available. The alarm verification delay shall be programmable from 5 to 30seconds and each zone shall be able to be selected for verification. The control panel shall keep a count of the number of times that each zone has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.

9.12.3 Point Disable: Any device in the system may be Enabled or Disabled through thesystem keypad.

9.12.4 Point Read: The system shall be able to display or print the following point statusdiagnostic functions:

9.12.4.1 Device status.

9.12.4.2 Device type.

9.12.4.3 Custom device label.

9.12.4.4 View analog detector values.

9.12.4.5 Device zone assignments.

9.12.4.6 All program parameters.

9.12.5 System Status Reports: Upon command from a system operator, a status report will be generated and printed listing all system status provided an optional RS232 card is installed. The report must also be exportable to a USB device on the USB port.

9.12.6 System History Recording and Reporting: The control panel shall contain a history buffer that will be capable of storing up to 2000 events (1000 alarm and 1000 trouble). Each of these activations will be stored and time-and-date stamped with the actual time of the activation. The contents of the history buffer may be manually reviewed, one event at a time, exported to a USB device or printed (if optional RS232 module is provided) in its entirety.

9.12.6.1 The history buffer shall use non-volatile memory. Systems that usevolatile memory for history storage are not acceptable.

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9.12.7 Automatic Detector Maintenance Alert: The control panel shall automatically interrogate each intelligent smoke detector and analyze the detector responses over a period of time.

9.12.7.1 If any intelligent smoke detector in the system responds with a reading that is below or above normal limits, the system will enter the trouble mode and the particular detector will be annunciated on the system display. This feature shall in no way inhibit the receipt of alarm conditions in the system nor shall it require any special hardware, special tools or computer expertise to perform.

9.12.8 Pre-Alarm Function: The system shall provide 2 levels of pre-alarm warning to giveadvance notice of a possible fire situation. Both pre-alarm levels shall be fully field adjustable. The first level shall give an audible indication at the panel. The second level shall give an audible indication and may also activate control relays. The system shall also have the ability to activate local detector sounder bases at the pre-alarm level to assist in avoiding nuisance alarms.

9.12.9 Software Zones: The control panel shall provide 512 programmable software zones. All addressable devices may be field programmed to be grouped into these zones for control activation and annunciation purposes.

9.13 Batteries:

9.13.1 Batteries shall be 12 volt (2 required).

9.13.2 Batteries shall have sufficient capacity to power the fire alarm system for not less than 24 hours in standby plus 5 minutes of alarm upon a normal AC power failure.

9.13.3 Batteries are to be completely maintenance free. No liquids are required. Fluid level checks, refilling, spills and leakage shall not be accepted.

## 10.0 PROGRAMMABLE ELECTRONOC SOUNDERS

**10.1** Electronic sounders shall be UL Listed or FM Approved and operate on 24 VDC nominal.

**10.2** Electronic sounders shall be field programmable without the use of special tools to choose 1 of 8 tones with an output sound level of at least 90 dBA measured at 10 ft (3.0m) from the device.

**10.3** Electronic sounders shall be flush or semi-flush mounted as shown on plans.

## 11.0 VISUAL NOTIFICATION APPLIANCES

**11.1** Strobe lights shall operate on 24 VDC nominal.

**11.2** Strobe lights shall meet the requirements of the ADA as defined in UL standard 1971and shall meet the following criteria:

11.2.1 The strobe intensity shall meet the requirements of UL 1971 and devices shallbe multi-candela 15 cd – 110cd and higher intensity if required by the plans.

11.2.2 The flash rate shall meet the requirements of UL 1971.

11.2.3 The appliance shall be placed 80 in.(to the bottom of the appliance) to 96 in. (tothe top of the appliance) above the finished floor within the space

## 12.0 VISUAL / VISUAL COMBINATION DEVICE

**12.1** Audible/visual combination devices shall meet the applicable requirements of Section

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10.0 listed above for audibility.

12.2 Audible/visual combination devices shall meet the requirements of Section 11.0 (listedabove) for visibility.

## 13.0 ISOLATOR MODULE

13.1 Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.

13.2 If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolatormodule shall automatically reconnect the isolated section.

13.3 The isolator module shall not require any address-setting and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator moduleafter its normal operation.

13.4 The isolator module shall mount in a standard 4 in. (102 mm) deep electrical box or in a surface mounted back box. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

## 14.0 ABORT SWITCH

14.1 The abort switch shall be used where an investigative delay is desired between detection and actuation of the fire suppression system.

14.2 This switch shall be a momentary contact "dead-man" type switch requiring constant pressure to transfer one set of contacts. Clear operating instructions shall be providedat the abort switch.

14.3 This switch shall be rated for 2 A resistive @ 30 VDC.

14.4 The terminal connections shall be of the screw type.

## 15.0 MAINTENANCE LOCK-OUT SWITCH

15.1 The maintenance lock-out switch shall be used where it is desired to disable the firesuppression system during routine maintenance.

15.2 This switch shall be key operated allowing removal of the key only in "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-Out" position. The control unit is used to indicate a supervisory condition when in the "Lock-Out" position.

15.3 The switch shall include 1 set of normally open and 1 set of normally closed control contacts rated for 2 A resistive @ 30 VDC.

15.4 The terminal connections shall be of the screw type.

## 15.0 SELECTOR SWITCH

15.1 The selector switch shall be used where a connected reserve is required.

15.2 This switch shall be key operated allowing removal of the key in either the "Main" or "Reserve" position.

15.3 This switch shall be rated at 28 VDC @ 1.1 amp make/break or 6 amp continuous carry.

15.4 The terminal connections shall be of the screw type.

## 16.0 PIPE MATERIAL

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16.1 System piping shall be of non-combustible materials having physical and chemical characteristics such that its integrity under stress can be predicted with reliability.

16.2 Piping materials shall be Schedule 40 black iron, galvanized, chrome-plated, or stainless steel pipe conforming to ASTM A-53 or ASTM A-106.

16.3 Under no conditions shall ordinary cast iron pipe or fitting be utilized.

16.4 Piping joints shall be suitable for the design conditions and shall be selected with consideration of joint tightness and mechanical strength.

16.5 As a minimum, fittings shall be black, 300 lb class fittings conforming to ANSI B-16.3.

16.6 All piping shall comply with NFPA 2001.

16.7 Piping shall be installed in accordance with good commercial practice to the appropriate codes, securely supported with UL Listed hangers and arranged with close attention to the design layout since deviations may alter the design flow performance as calculated.

16.8 Piping shall be bracketed within 12 in. (305 mm) of all discharge nozzles.

16.9 All piping shall be reamed, blown clear and swabbed with appropriate solvent to remove mill varnish and cutting oils before assembly.

16.10 Pipe unions are acceptable.

16.11 Reducing bushings and reducing fittings are allowed when reducing pipe size.

16.12 Dead end pipe lines to be provided with a capped nipple, 2 in. (51 mm) long.

16.13 Vertical drops on end of line are acceptable.

16.14 Assembly of all joints shall conform to the appropriate standards. Threaded pipe joints shall utilize Teflon tape applied to the male threads only.

## 17.0 EXTINGUISHING AGENT

17.1 The fire suppression agent shall be 3M Novec 1230 Fire Protection Fluid manufactured by3M Company, St. Paul, MN or their approved supplier.

17.2 Agent shall not contain any Hydrofluorocarbons (HFC).

## 18.0 STORAGE CYLENDER

18.1 Clean Agent Tanks shall be super- pressurized with dry nitrogen to an operating pressure of 360 psi at 70 °F (24.8 bar at 21 °C). Tanks shall be of high-strength low alloy steel construction and conforming to NFPA 2001.

18.2 Tanks (master) shall be actuated by either a resettable electric actuator or by pneumatic means from a nitrogen cartridge located in the releasing device. Explosive devices shall not be permitted.

18.3 Each tank shall have a pressure gauge and low pressure switch (optional) to provide visual and electrical supervision of the container pressure. The low-pressure switch shall be wiredto the control panel to provide audible and visual "Trouble/Supervisory" alarms in the event the container pressure drops below 290 psi (20.0 bar). The pressure gauge shall be color coded to provide an easy, visual indication of container pressure.

18.4 Tanks shall have a pressure relief provision that automatically operates when the internalnominal pressure is between 710 and 790 psi (50.0 and 54.5 bar).

## 19.0 TANK BRACKET

19.1 Each tank assembly shall be furnished with at least one mounting bracket consisting of anut, bolt and two bracket straps. The back channel must be supplied by others.

19.2 Tank brackets shall be UL listed and/or FM approved for use with the fire suppressionsystem.

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## 20.0 VALVE ACTUATORS

20.1 Electric valve actuators shall be of steel body, stainless steel actuation pin and brass swivelconnections to allow removal of actuators for maintenance or testing.

20.2 Operation of actuators shall not require replacement of components. NO ELECTRO-EXPLOSIVE DEVICES may be used to actuate the valve assembly.

20.3 Electric actuators shall be continuous duty type for 24 VDC operation.

20.4 Actuation devices shall be UL listed and/or FM approved for use with the fire suppressionsystem.

## 21.0 DISCHARGE HOSE/CHECK VALVE

21.1 When manifolding, all cylinder assemblies shall include a flexible discharge hose and checkvalve for connection to the manifold inlet.

21.2 All hose/check valves shall be UL listed and/or FM approved.

## 22.0 DISCHARGE NOZZLES

22.1 Discharge nozzles shall be of one piece construction and sized to provide flow rates inaccordance with system design flow calculations.

22.2 The orifice size shall be determined by a computerized UL listed flow calculation program.

22.3 Orifice(s) shall be machined in the nozzle body to provide a horizontal discharge patternbased upon the approved coverage arrangements.

22.4 Nozzles shall be permanently marked with the manufacturer's part number. The nozzlesshall be threaded directly to the discharge piping without the use of special adapters.

22.5 Nozzles shall be UL listed.

## 23.0 SYSTEM CHECKOUT AND TESTING

23.1 The completed installation shall be inspected by factory authorized and trained personnel. The entire system shall be checked out, inspected, and functionally tested by qualified, trained personnel, in accordance with the manufacturer‘s recommendation procedures andNFPA standards.

23.2 Inspection shall be performed in the presence of the owner's representative, architect's or engineer's representative, insuring authority and/or the local AHJ.

23.3 All mechanical and electrical components shall be tested according to the manufacturer's recommended procedure to verify system integrity.

23.4 Inspection shall include a complete checkout of the detection/control system and certification of cylinder pressure. A written report shall be filed with the owner.

23.5 As-built drawings shall be provided by the contractor (2 copies) indicating the installation details. All routing of piping, electrical conduit and accessories shall be noted.

23.6 Equipment installation and maintenance manuals shall be provided in addition to the as-built drawings.

23.7 Prior to final acceptance, the contractor shall provide operational training in all concepts ofthe system to the owner's key personnel. Training shall consist of:

23.7.1 Control system operation

23.7.2 Trouble procedures

23.7.3 Abort procedures

23.7.4 Emergency procedures

23.7.5 Safety requirements

23.7.6 Demonstration of the system (excluding SAPPHIRE release)

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STATE BANK OF PAKISTAN PROJECT MANAGEMENT DIVISION ENGINEERING DEPARTMENT SBP BSC HOK

23.8 The quantity of agent shall reflect the actual design quantity of clean agent.

## PART-4 SYSTEM ARRANGEMENT

### 24. FIRE SUPPRESSION SYSTEM

24.1 Fire suppression system shall be of the engineered, permanently piped, fixed nozzletype with all pertinent components.

24.2 All agent storage tank(s) shall be centrally located as vertical, free-standing with wall mounted retaining brackets. Where multiple cylinders are required for the same hazard, acommon manifold shall be employed.

24.3 On multiple cylinder arrangements (discharging into a common hazard), one cylinder shallbe designated as the pilot cylinder and employ the restorable electric actuator, and mechanical manual actuator, or both. All remaining cylinders shall be pneumatically operated from the clean agent.

24.4 Manifolded cylinders shall employ a flexible discharge hose to facilitate installation andsystem maintenance. Each cylinder on a manifold shall also include an agent check valve installed to the manifold inlet.

### 25. FLOW CALCULATIONS

Computerized verification of flow calculations shall be submitted for each part of fire suppressionsystem and include the following data as a minimum:

25.1 Quantity of agent per nozzle

25.2 Nozzle orifice diameters

25.3 Pressure at nozzle (psi)

25.4 Nozzle body nominal pipe size (inch)

25.5 Number and size of cylinders

25.6 Total agent

25.7 Pipe size per pipe section

25.8 Pipe schedule per pipe section

25.9 Number, size and type of fitting per pipe section

25.10 Actual length per pipe section (feet)

25.11 Equivalent length per pipe section (feet)

25.12 Discharge time (seconds)

## PART-5 WARRANTY

26.1 **Environmental:** The manufacturer shall offer a 20-year warranty covering regulations banning or restricting use of the clean agent due to environmental issues.

26.2 **Components/System:** Limited one year warranty shall be offered for defects inworkmanship and material.

# SURVEILLANCE AND COMMUNICATION NETWORK

# CLOSED CIRCUIT TELEVISION SYSTEM (CCTV)

## 1.0 SCOPE OF WORK

The State Bank of Pakistan (SBP) is striving to establish a State of Art building in thecity of Rahwali Gujranwala within the next few years, able to comply with the current and future needs of Gujranwala. A major component of such a system is Security and Surveillance strategy.

The intelligent building that would transform our civilization. But the much-desired and talked-about intelligent building is hard to find today, even though the concept has been around since the '70s. There are several factors that may have contributed to this state of affairs. Over the past decades, new technologies have generated a trend toward a merging of communications and industrial control signaling methods.

Different technologies offer unique advantages, however, all require a robust and reliable physical (cabling) layer. This must support the higher layers of the open systems interconnect (OSI) architecture. The integration of different technologies depends on standards-based solutions. They play an essential role in the concept of the intelligent building.

The current document deals with the conception and definition of "Security and Surveillance, IT and communication system in overall SBP Building" which will bethe basis for the definition of requirements in the Terms of Reference (TOR) and Request for Proposal (RFP).

Due to recent terrorist attacks in all over the Pakistan and especially at public places and increasing threat of terrorist attacks on government properties / facilities, there isimmediate need for a surveillance system by which the security officials will be able to monitor the activities of suspects and exercise general surveillance of public places. This will help in reducing the opportunities available to terrorists. For this purpose a CCTV Surveillance security system is required for the 24/7 monitoring. The system will consist of security cameras of different capabilities which can workin both day and night and in any weather conditions. Cameras will cover the whole building and a monitoring room will be established for the centralized monitoring and storage of the video stream of each camera. Cameras will be installed in such a way that they will cover the maximum area and keep a close vigilance on the entry/ exit points of building, There will also be a secured provision of remote monitoring from any location via internet.

CCTV Surveillance System, Connectivity (Fiber Optic), Server/Racks/Storages, Video Wall, UPS, Data Cabinet, for the whole building and nearest territory.

The IT Systems comprises the following core components along with associated equipment and services:

- CCTV Surveillance System
- Monitoring and Controllers
- Computer Servers, Infrastructure Racks (Imported) & Data Storages
- UPS
- Connectivity (Fiber Optic)

High-level requirements for these systems are outlined in relevant sections in this document.

The work under this section consists of supplying, installing, testing, connecting and commissioning of all materials and services of the complete CCTV system as specified herein, or as given in the Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at the site with other services for exact route, location and position of the electrical lines and equipment.

The CCTV system with accessories shall also comply with the General specifications for Electrical Works, Section - 8001 and with other relevant provisions of the Tender Documents.

## 2.0 DELIVERABLES

The general report of the present work package will describe the technical system to implement Security and Surveillance System based on the feasibility study. This will include the CCTV Cameras, network video recorder (NVR), Data Storage equipments, image and video transfer or communication network plan design, telephonic system and specification for SBP Building.

The following deliverables will be submitted to the Authority at the end of the study:

- Detailed technical concept (this document)
- BOQ
- Detail Drawings and Symmetric Drawing

## 3.0 PURPOSE OF THIS DOCUMENT

The present document describes detailed concept for the above issues. It includes all decisions, comments and hints, which were made or given during the meetings and during the presentations and studies before.

Upon discussion of this detailed concept and Authority approval, the tender. Documents will be prepared.

## 4.0 GENERAL

A telecommunication cabling system for building that will reduced cost over life of cabling due to less re-cabling, less down time, less office disruption and productivity loss. All structured cabling based upon TIA/EIA TSB-72.

These systems provide the benefit of improved IT, Communication and emergency response to both the security staff and the public. Cameras can allow central dispatch to continually monitor and assess the any situation to determine appropriate help by building security, law enforcement or other forms of emergency response (i.e., medical aid, Hazmat, terror threat).

A security staff/agency benefit is increased surveillance of building properties and vault, with limited staffing requirements and high-quality archival data. These systems provide strong evidence for criminal investigations, LEA investigation/adjudication and related onboard incidents (fare evasion, physical assaults, etc.).

Such systems are also perceived to reduce vandalism and crime, including operator assaults. They may also contribute to increasing passengers' sense of safety, though they may also have the adverse effect of heightening anxiety if CCTV is viewed as an indicator of a high-risk environment.

The CCTV System shall be used for general surveillance of building area of Building. Operator switching from or to any camera shall be by keyboard with joystick. The camera number and location shall be displayed on the monitor. The system shall be designed for 24 hour operation.

All the active items of the CCTV System shall be listed as a product of a single manufacturer.

The power to all equipment of the CCTV system in building shall be supplied by an AC uninterruptible power supply (UPS) which shall have an autonomy of one hour.

## 5.0 APPLICABLE STANDARDS AND CODES

The following standards and codes shall be applicable for the material covered within the scope of the section.

| | |
|---|---|
| IEC 801 – 2 | Electrostatic discharge |
| IEC 801 – 3 | Radiated Electromagnetic interference |
| IEC 801 – 4 | Voltage transients |

Install all the signal transmission components in accordance with the relevant standard ANSI Locate all surge protection within are meter of building entrance:

| | | |
|---|---|---|
| - | Dust and rain resistance | IP66 for outdoor cameras. |
| - | Salt mist | According to IEC 68-2-11 (for outdoor cameras) |
| - | Vibration | According to IEC 68-2-6 |
| - | Bump test | According to IEC 68-3 |

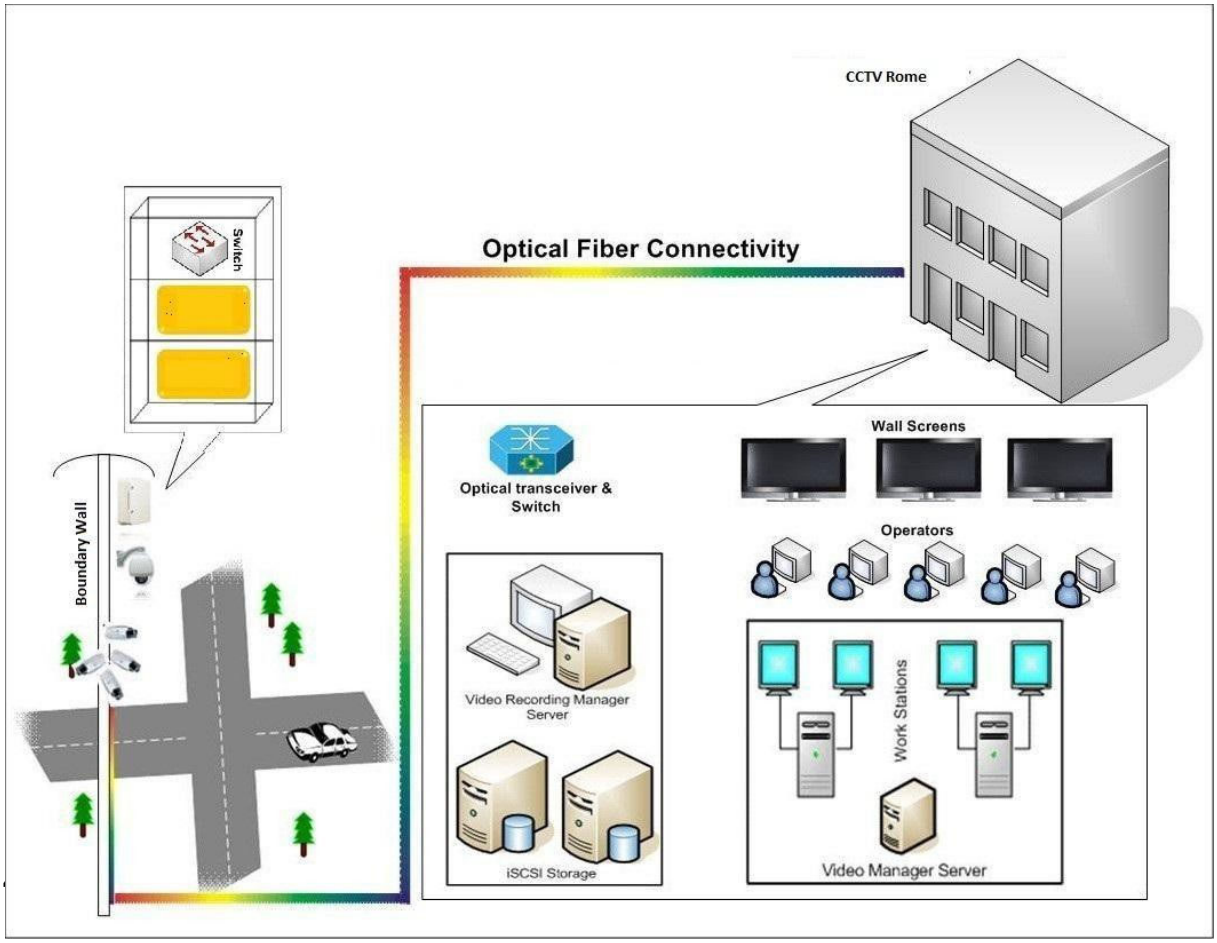
## 6.0 EQUIPMENT OVERVIEW

In the following a short description of all involved equipment will be given. More detailed information about functionality, data exchange etc. can be found in next chapters.

The proposed IP based Surveillance and Recording System hereafter referred to as CCTV shall be an integrated system shall consist of, but not limited to, the following components:

- Video Management System (VMS) including necessary hardware, software andlicensing.
- Video Recording Management (VRM) system with redundant storage.
- Operator and supervisor workstations including PCs, desktop monitors, PTZ joystick.
- Wall mounted Digital LCD Video Monitors for Video Wall.
- Outdoor Fixed Color (Day/Night) IP Cameras.
- Pan/Tilt/Zoom (PTZ) Color Day/Night Dome IP Cameras.
- Camera enclosures as required.
- Network Switches and routers with necessary passive.
- UPS for Backup Power Supply.
- Optical fiber connectivity for outdoor cameras mounting

The following diagram presents the general principle of the Security and surveillance system communication diagram.




- Customizable branding and appearance Server, encoder, NVR and camera administration Parameters management.
- Scheduled and event-tagged video recording.
- Record on motion capabilities.
- User and role management.
- Detailed activity reports and system audit.
- Ability to push predefined views to any number of monitors with VideoSurveillance Virtual Matrix.
- Ability to schedule to operator shifts, event filters, temporary views.
- Flexible video displays.



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- Views with both live and archived video.
- PTZ controls and presets.
- Digital zoom and instant replay.
- Archive review and clipping.
- "Record Now" feature while viewing live video.
- Event setup and event notifications.
- Ability to search video based on motion.
- SAN, NAS, and DAS configurations support.
- Total RAW storage should be at least 172 TB.
- RAID 5 configuration.
- High availability server specifications for24x7 operation.
- Redundant power supplies.
- A standards-based architecture that provides the flexibility to use a broad rangeof devices, codec, viewing platforms, and network topologies.
- Plug-and-play support for encoders, NVRs, and fixed and pan-tilt-zoom Cameras.
- Low-latency video with high-quality images, including megapixel resolution.
- Simultaneous support for JPEG, MPEG-4, and H.264.
- Unparalleled scalability in terms of number of sites, cameras, viewers, and Storage.
- Archives at different frame rates, durations, and locations.
- Efficient redundant multi-site archiving that conserves bandwidth.
- Loop- and event-based video and audio recording.
- Distribution to video wall for command centres Video access for 24x7monitoring.
- Easy integration with intelligent systems.

- Minimized load on video servers platforms by streaming only the active video channels.
- Backup utility that supports configurations of devices, archives, events, and PTZ for a quick and easy restore to a secondary server

### 6.1 Fixed IP Colour Day / Night Camera Function

- User management.
- Directly IP based without requirement of encoder.
- Day/Night camera. Should switch automatically to monochrome mode (black andwhite) at night.
- Imaging Device 1/3 inch complementary metal oxide semiconductor (CMOS)with wide dynamic range.
- Image Control with Automatic white balance (AWB), automatic back lighting, automatic gain control (AGC).
- Iris setting should be auto/manual with definitions for sharpness, image qualityand also time stamp and camera ID.
- Dynamic Range 102 dB typical/120 dB maximum.
- Minimum Illumination :
    - Colour mode: F1.4 @ 0.4 lux (.04 fc).
    - Black and white mode: F1.4 @0.04 lux (0.004 fc)
- Lens Mount CS mount (15 to 50mm lens required).
- Video Compression MPEG-4 and H.264.
- Resolution and Frame Rate on PAL:
- 704 x 576 @ 25 fps PAL (minimum required).
- 1920 x1080 @ 25 fps PAL (maximum required).
- Should support dual Video Streaming with both streams originatingindependently form the camera.

- Should support multicasting.
- Should support 2 -way audio.
- Should have built in microphone with additional support for external microphoneand speaker.
- Audio Compression G.711 A-Law G.711 U-Law, G.726.
- Should support Power over Ethernet(PoE) 802.3af.
- Should provide at least two digital inputs and two digital outputs for hardwire integration.
- Should support Quality of Service (QoS) through DSCP support and additionally, should Support Constant Bit Rate or Variable Bit Rate (constant quality), and Variable Bit Rate with ceiling (bandwidth management by reducing frame rate rather than quality).
- Camera should provide 802.1Xauthentication.
- Camera should support 128 bit hardware-based Advanced Encryption Standard (AES).
- Should have built in motion detection with at least 3 user-definable detection areas.
- Should support e-mail alert and FTP uploading of captured video or JPEG snapshots triggered by motion alert.
- Multiple user access levels with password protection.

## 6.2 Pan / Tilt / Zoom Day / Night Outdoor Colour Dome Camera

- The camera should be IP based with a built-in 100Base-TX network interface.
- The camera should be true outdoor model suitable for use in Pakistan.
- Imaging device should be 1/4 inch CCD and support both colour and monochrome black and white. With540 TVL horizontal resolution.
- Should provide 35x optical zoom and 12 x digital zoom with auto focusfeature.
- The camera should provide high- quality MPEG-4, MJPEG or H.264 compressed images.

- The camera should provide images @4CIF i.e. with a resolution of 704x576 pixels in PAL mode.
- The supported frame rate should be30fps or 25fps in PAL mode.
- The camera should support two simultaneous streams.
- Should support Day/Night mode and should switch automatically to monochromemode at night with below 1 lux sensing at variable shutter speeds.
- Should provide super quick, 400° per- second pan and 200° per-second tilt speeds with 256 pre-set positions. Each pre-set position should support the programmable camera settings such including selectable auto focus modes, iris level, Low Light limit, and backlight compensation for each preset.
- Should support wide dynamic range (128 x) appropriate for high contrasting environments.
- Should support automatic focus, automatic Iris control, gain control horizontal and vertical aperture control.
- Should be installed in a High-impact, weather-resistant dome enclosure.
- Camera must provide at least 7 Inputs and 2 outputs that can be programmed individually. Inputs should be able to trigger an alarm condition. Outputs should be able to drive an external device.
- Should support intelligent privacy masking.
- Should support 8 user-defined programmable patterns including pan/tilt/zoom and preset functions, and pattern programming through control keyboard or through dome system on-screen menu.
- Should support a web interface utility for 5 simultaneous users when using MJPEG/MPEG-4 in unicast mode.
- Should support H.264 Compression.
- Should support On-screen display for time, date and location.
- Should support On-screen display of compass heading and user-definable compass Setup.
- Should support multi level password protection.

- Should support encrypted viewing through Secure Sockets Layer (SSL).
- Should support 128 bit encryption.
- Turnstiles or tripod Gates.
- All the system runs stable with little noise and no mechanical impact.
- It can self-check and alarm which will be make it convenient to use.
- It can work one direction permitted, one forbidden, or one direction charged, one for free, and all the working modes can be set by the buttons in the main control board.
- Beam can be lifted and fall when electricity is cut-off.
- It must be standard electrical interface which can be connected with various kinds of reader and writer equipment.
- So all the functions can be realized in one integration machine and can be controlled and managed by the computer in the far distance.
- The number of the persons who have passed by can be counted automatically which can also be displayed in LED.
- Direction-guide lights are in the turnstile to tell you which direction can go or which cannot.
- The function with or without card-reading memory according to requirement.
- The number of the persons who can pass by the turnstile can be set to meet the requirement of some special occasions.
- After reading the card, if the person who punched the card does not pass itwithin the set time, then this chance to access will be cancelled, and the set time can be changed according to your request.
- Full-automatic.
- Arm length 510mm.
- 304 Stainless Steel.
- Thickness of Housing 1.50mm or >1.26mm stainless steel.
- Dimension of Housing (L×W×H mm) 1235×280×1000.

- Input Interface DC12V electrical level signal, more than 100ms, or DC12V impulse signal driving current, more 10mA.
- Power consumption: 30W.
- Transit Speed 30~40 persons/min

### 6.3 Access Control for Security Gates

- Support Wiegand data format between 24 and 72 bits, also compatible with ABA(track two).
- Support TCP/IP to allow the system to be used across Local Area Networks(LAN) and Wide Area Networks (WAN).
- Connect to 127controller using RS-485.
- Multi format readers (for example: EM, MIFARE, HID Prox, HID iClass, Indalaand Biometric).
- Delivered in mild steel cabinet complete with 230-16V AC shielded Transformer,Fuse block, 12V 2A DC regulated power supply and cabinet lock.
- 5 years Lithium cell for maintaining memory and real time clock.
- Data can be stored up to go days without power.
- Power Supply Fully Automatic (100 to 240 VAC).
- Support 1 Door, one or Two directions.
- Sensitivity Level -99 to +99.
- Reader Inputs: TTL level, 12V DC, 150mA
- Exit Button Input: Normally Open (N.O)

### 6.4 U Network/Server Rack

- Contemporary, sleek appearance, Strong frame structure
- Multiple vendor equipment compatibility
- Full line of accessories & a Family of sizes and styles
- Width: EIA Standard 19″ Rack Rails
- External Width: 23.6″ – 600mm
- Depths: 39.37″ & 41.34″

- Height: 78.74″ – 2,000mm – Rack Units: 42U
- Racks in other dimensions are available.
- Sidewalls, Split rear doors
- Baying Kits, tool less Shelves, casters, Bolt Down Kits, Cable Management
- Power Strips – vertical or Rack mount, Enclosure Monitoring System
- Tool less Blanking Panels, Fans

### 6.5 U Network Rack

- Contemporary, sleek appearance, Strong frame structure
- Multiple vendor equipment compatibility
- Full line of accessories & a Family of sizes and styles
- Width: EIA Standard 19″ Rack Rails
- External Width: 23.6″ – 600mm
- Depths: 31.5″
- Height: 49″Rack Units: 24U
- Racks in other dimensions are available.
- Sidewalls, Split rear doors
- Baying Kits, tool less Shelves, casters, Bolt Down Kits, Cable Management
- Power Strips – vertical or Rack mount, Enclosure Monitoring System
- Tool less Blanking Panels, Fans

## 7.0 INSTALLATION

Installation of CCTV System shall be done in strict accordance with manufacturer's the recommendations.

## 8.0 MEASUREMENT AND PAYMENT

### 8.1 General

The Contractor bid amount, against each Bill of Quantities item as given below, shall include design, supply, installation, testing, commissioning and completion for all work specified herein and / or as shown on the Tender Drawings related to the item.

## 8.2 Cameras / Lenses and Monitors

8.2.1 **Measurement:** Measurement shall be made for the total number of cameras/lenses and monitors with accessories acceptably supplied and installed by the Contractor as a complete unit.

8.2.2 **Payment:** Payment shall be made for the number of units measured as provided above at the Contractor unit price and shall constitute full compensation for supplying, installing connecting, testing and commissioning of the monitors and cameras / lenses including all mounting arrangement / racks, etc. and all accessories.

## 8.3 DVR / Controller

8.3.1 **Measurement:** Measurement shall be made for the DVR/Controller acceptably supplied and installed by the Contractor as a completejob.

8.3.2 **Payment:** Payment shall be made for the number of job measured as provided above at the contract unit price and shall constitute full compensation for supplying, installing and completion of the DVR/Controller including all control equipment for operation and control of system, mounting racks and interconnections etc.

## 8.4 Cat-6A / Data Cable

8.4.1 **Measurement:** Measurement shall be made for the total running meter of data cabling for each camera acceptably supplied and installed by the Contractor as complete unit.

8.4.2 **Payment :** Payment shall be made for the total number of units measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, testing and commissioning of all type of power and video wiring and conduiting/piping including all accessories related to the items.

## 8.5 Operator Console

8.5.1 **Measurement:** Measurement shall be made for the CCTV System Operator Console including chair acceptably supplied and installed by the Contractor as a complete job.

8.5.2 **Payment :**Payment shall be made for the complete job measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, testing and commissioning of monitors, keyboard and DVR in the Console and all accessories.

### 8.6 Camera Adaptor

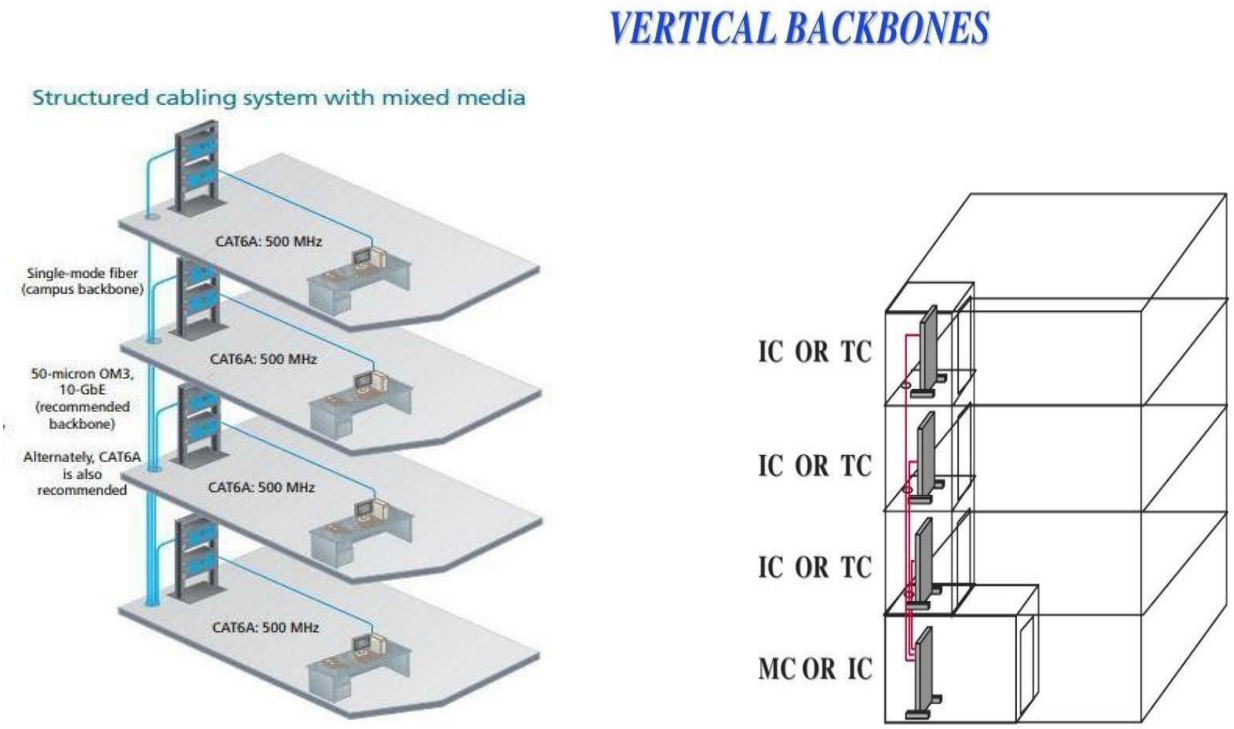
8.6.1 **Measurement:** Measurement shall be made for the each camera adaptor acceptably supplied and installed by the Contractor as acomplete unit.

8.6.2 **Payment:** Payment shall be for the number of units as provided above at the contract unit price and shall constitute full compensation for supplying, installing, testing and commissioning of adaptor including all accessories related to the item.

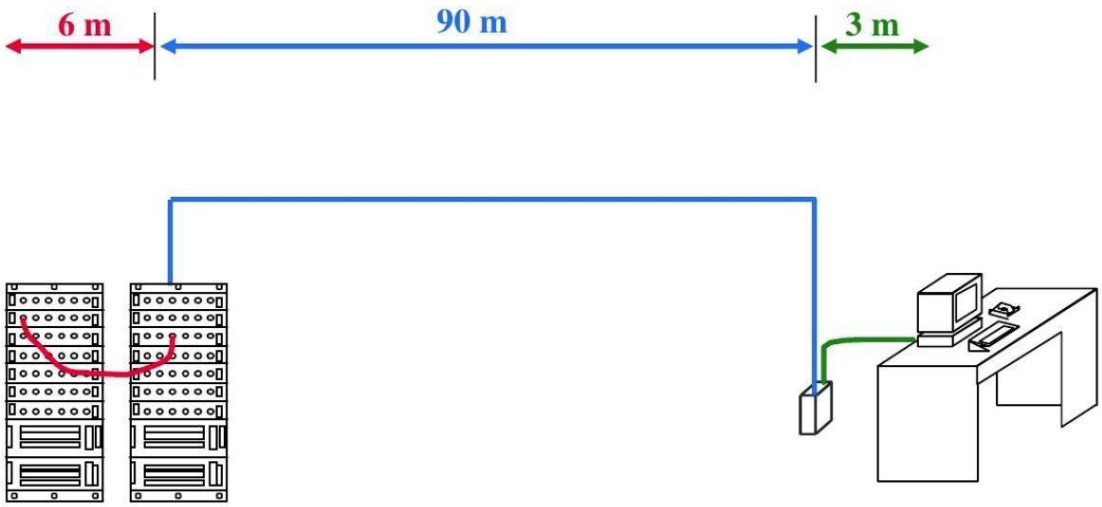
## 9.0 DESIGN CONSIDERATION

### 9.1 Network Requirements

An IP network which connects SBP Building inside and outside for Local campus network and CCTV cameras connected with Gigabit Passive Optical Network (GPON). With a clear understanding of the relationship among cameras, video zones, building, a structural view can be drawn as shown in Figure.



## Horizontal Distances




Video live viewing, archiving, archive playback functions are supported at sites. The network must have sufficient network bandwidth, and plan for future networkgrowth (30%).

- Network recovery time <= 50ms

### 9.2 System Structure

Each building and its levels network devices divide into group Depending on their roles and physical locations, which share similar networking characteristics. The ¯groups‖ are the building blocks of a network. Within the group, networking services like switching, routing, redundancy, security, traffic prioritization, etc. can be planned and deployed accordingly.

The following communication media services will typically be used:

1. Ethernet LAN connections at latest available security, speed andreliability levels using fibre and copper media.
2. WAN connectivity using several media connectivity which can be in- house (Fiber) maintained or be provided by operators (e.g. MPLS networks). Using LTE radio network to generate redundancycould be an option as well.

Existing solutions support all kind of communication media and are only restricted by capacity limitations in the media. Details and suitable setups are discussed in the feasibility for the communication network.

The following is a brief description of each of the major segment of the network. The next sections describe the design of each of the network segment.

a) Backbone Communication Infrastructure: This the high bandwidth data highway linking all elements of every floor/level of both building, volte area, security posts and entire boundary wall. This is the core layer of the network and must provide sufficient bandwidth for all elements of IT equipment's to seamlessly work together. High availability and redundancy must also be the key consideration in the design of this partof network.

b) Local Area Network of each Floor: This part of network must link the devices such as Workstation, Security cameras, VOIP Phone and other IT elements within a floor with each other and to the aggregation layer above in network hierarchy.

c) Server and CCTV Room: The Server and CCTV Room must house the data centre, the monitoring workstations, security monitoring stations, the Network management, VOIP Server and all other central elements of IT. The backbone network devices must be housed at Server Room. It must also have the Local Area Network among all the workstations and between the servers and the backbone network elements.

d) Boundary wall Camera Network: This must link the feed from all the cameras on the wall to the wall via optical Fiber and use media convertor.

The entire building will be covered with IP cameras bearing resolution of 2 to 6 MP or above. Cameras installation points marked by SBP Security Staff some changes made by consultant.

Following are the types of cameras:

a) PTZ (IP) Camera
b) Dome (IP) Cameras
c) Bullet (IP) Cameras
d) ANPR (IP) Camera

## 9.3 External Camera

These cameras will be installed at wall and key points of infrastructure. Cameras will be install on every entry gates and adjacent area of building fix high resolution bullet IR IP weather proof cameras and PTZ IR IP Camera. Every camera must be cover 45~50 meter distance. Every camera installed boundary wall have a steel box/Handhole for fiber 1:2 ONU switch, power outlet, all cameras connected to GPON throughout with server room.

## 9.4 Building Camera

Cameras on building floor will be install on public access area, Entry and Exit Gates, Turnstiles, Bus Platform elevators, stairs, inside lifts and IT Room, every floor have dome IP IR camera, fish eye IP IR camera, PTZ IR IP Camera and remaining are Bullet IR IP cameras all cameras are IP based, all cameras connected CAT-6 copper cable throughout the single floor, 6 core fiber cable also use as need every floor distribution unit to IT room.

The entire network should be able to transport data traffic among cameras, workstations and servers. (CCTV camera quantities and locations are listed in Figure 2-1.) These cameras capture video and send video data over the network for viewing and archiving.

| Site | Camera Total Q'ty | Dome Camera | Bullet Camera | Fish Eye Camera | PTZ Camera |
|---|---|---|---|---|---|
| Basement-2 | 0 | 0 | 0 | 0 | 0 |
| Basement-1 | 72 | 54 | 9 | 9 | 0 |
| Ground-Floor | 57 | 42 | 10 | 4 | 1 |
| Mezzanine-Floor | 76 | 69 | 6 | 0 | 1 |
| First-Floor | 69 | 64 | 4 | 0 | 1 |
| Second-Floor | 47 | 46 | 1 | 0 | 0 |
| Roof | 5 | 1 | 4 | 0 | 0 |
| Upper-Roof | 2 | 2 | 0 | 0 | 0 |
| External Wall 6 MP | 43 | 0 | 43 | 0 | 0 |

## 10 PROCESSES

The following figure gives an overview about data exchange between the Level 3 and the in the following the interaction between the system levels and involved devices isdescribed.

### 10.1 Technical Process / System Process

#### 10.1.1 Security and Surveillance

a) Deterrence of acts of terrorism. This requirement is to be satisfied by monitoring of sensitive areas such as volte area, staircases and elevator access, parking lots and access paths, elevator and whole Building, and adjacent area. These cameras provide direct alerts in the case of boundary intrusion, or a left object on any area. In the event of an incident alert occurring all incidents are recorded permanently.

b) Protection of Building from unauthorized access. This requirement entails the installation of surveillance cameras and access control system at areas where unauthorized personnel may attempt to gain access, and then engage in robbery or vandalism of property. Accordingly, CCTV cameras are installed at sites such as access

gates to provide spot coverage, at watch points on peripheral fences to provide linear coverage, and with wide-angle cameras at critical areas such as external wall. In addition to these outside cameras, CCTV cameras are mounted at storage room doors. Both fixed and moveable Pan-Tilt-Zoom (PTZ) cameras are installed, ANPR camera install at main gate to record all vehicle number plate, permanentlyrecording all passersby.

c) Comprehensive and authenticated incident recording. This requirement calls for the provision of a high quality camera image recording system. All camera images are recorded all the time. Depending upon the presence or absence of an incident, or some other factor, camera images are either deleted after a period of time, or sent to local or remote archival storage for later forensic or other use.

## 10.2 Operational Process

a) Communications process. The system will utilize the extensive Gigabit Passive Optical Network (GPON) capability. This system is use for backbone network, to all area, and to other facilities. The system is designed as a ring system, with multiple cross modes and connectivity. The IT Network, CCTV Surveillance system and VOIP is required to operate using the TCP/IP protocol. Extensive network security protocols are in use, and all connected systems and system components are required to undergo extensive security checks to ensure that the system is impervious to outside attack.

b) Storage and search process. The CCTV Surveillance storage system shall make use of readily available RAID or similar low-cost storage components. Image search and find systems shall be based on theuse of a relational data base using commonly available software programs, such as Microsoft SQL.

c) Interface process. All interfaces shall follow TCP/IP protocols, usingstandard Commercial off-the-shelf (COTS) servers for connectivity.

d) Administrative Interface process. User support connectivity process, internal system interfaces, operating system and other features pertinent to the CCTV surveillance system environment shall be made available to the Contractor after contract award. The operation controlcentre shall have the capability to handle all data communications functions in accordance with:

e) All external computer communications functions shall meet Security protocols, and must be tested and certified by the IT function prior to any activation with the communication network.

f) The Server room shall interface, via a fiber optics connection, the hub, bridge, and/or routing architecture shall interface computer network.

g) Provide a LAN that is non-proprietary conforming to IEEE 802 standards. LAN communications shall utilize TCP/IP.

h) Incident monitoring and recording. This requirement is to be satisfied by the installation of both short-term incident recording, and long-term archival storage of incident images in accordance with the following:

The video from each operating camera may need to be transmitted to the CCTV Room central monitoring facility, dedicated security staff for monitoring will be able to view video from all the cameras, wherever located. In addition, the monitoring staff have control (that is, priority control) of the PTZ function on cameras equipped with PTZ.

## 10.3 Essential Design Parameters

a) Precise camera capabilities and specifications provided above or based on site requirements, satisfaction of performance requirements, sensitivity, resolution, image size, coverage, and a comprehensive system design.

b) Storage device or storage system capabilities and specifications for CCTV Room provided Equipment detail or based on site requirements, satisfaction of performance requirements, storage size, access speed, and a comprehensive system design.

c) The CCTV surveillance system will be capable of intruder detection and alarm by means of remotely adjustable guard boundaries and determination of object size or color. When applied to any specific or sensitive area, it will be possible to program the intruder alarms to be energized either by a routine such as night time hours only, or weekend days only, or by specific on/off command from the system operators.

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# STRUCTURED CABLING

## 1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and services for Structured Cabling specified herein, as shown on Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the system.

The Structured Cabling work with accessories shall also comply with the General Specifications, Section – 8001 and with other relevant provisions of the Tender Document.

## 2.0 GENERAL

The Structured Cabling System shall consist of the following sub-systems.

- Work Area Sub-system
- Horizontal Sub-system
- Wiring closet Sub-System
- Backbone Sub-system
- System Interconnect Sub-system
- Active System

The Structured Cabling System shall comprise the following components:

a) Fiber optic Backbone Cable.

b) Fiber optic Patch Panels MTRJ/VF-45 type.

c) Fiber optic Patch Cords, MTRJ/VF-45 type.

d) Cat-5e UTP for Voice and Cat-6AUFTP for Data.

e) Cat-6AUFTP Modular/Configurable RJ45 data patch panel.

f) Cat-6 STP 4 pair data patch cord with RJ45/RJ45 plugs.

g) Cat-6 STP 4-Pair Data Drop Cords with RJ 45/RJ 45 plugs.

h) Front cable management.

i) Rear cable management.

j) Cat-5e UTP RJ 45 and Cat-6A STP RJ45 outlets.

The LAN Cabling System shall support the following systems, but not be limited tothese systems.

**Data Processing**

Mainframe access, Client Server, Enterprise Server, Messaging Systems and Electronic Mail, common document utilization, Client Database, Voice and Video,etc.

**Data Communications**

EIA-232-D, RS-422, RS-423, ISDN, Ethernet (10 Base-T, 100 Base-T and 1000 Base-T), 100 Base VG Any LAN, Token Ring, Fiber Distributed Data Interface (FDDI), Twisted Pair-Physical Medium Dependant (TP-PMD) and ATM (155 Mbs and 622 Mbs), etc.

## 3.0 APPLICABLE STANDARDS AND CODES

The following standards and all ―normative addendums‖ shall be applicable to thisdocument and must be adhered to for any installation work performed.

| | |
|---|---|
| EIA/TIA 568-A | Commercial Building Telecommunications Cabling Standard. |
| EIA/TIA 569-A | Commercial Building Telecommunications Cabling Standard<br>Pathways and Spaces. |
| TSB 67 | Transmission Performance Specifications for Field-Testing ofUnshielded Twisted-Pair Cabling Systems. |
| IEEE 802.3 | Wire Speed |
| Performance IEEE 802.1Q | VLAN |

## 4.0 MATERIALS

### 4.1 Equipment Sub-System

The Equipment shall consist of all items of common shared electronic communications equipment in the server room and communications rooms and any transmissions media required to terminate the equipment and distribution hardware.

### 4.2 Backbone Cabling Sub-System

The backbone cabling sub-system shall be the main route for cabling in the building.

The main features of a Backbone Cabling Sub-System shall be:

- To provide media to carry data signals between floors.

- Carry multiple signals simultaneously.
- The topology is GPON wired in Optical Fiber Cable.

## 4.3 Optical Fiber Cable

**Fiber Optic Cable – Indoor Applications**

The construction of the cable shall consist of a polyvinyl chloride (PVC)coated central strength member, surrounded by tight buffer coated optical fiber with additional strength members made up of Aramid yarn. All this construction shall be encased in a flame-retardant Polyvinyl Chloride (PVC) outer jacket.

The fiber optic cable shall be a compact flexible cable. Tight buffered cables, specifically designed for indoor applications, shall be suitable for riser backbone cabling.

The cable jacketing system shall be constructed of flame retardant material and shall be riser rated in accordance with NEC Article 770, UL Subject1666.

| | |
|---|---|
| Cable | Buffered fibers surrounded by outerjacket |
| Outer Jacket | Flame retardant Polyvinyl chloride PVC |
| Outer Jacket Color | Orange |
| Flammability | Meet the requirements of NECArticle 770 for type OFNR. |
| Fiber Type | Multi-mode Meets FDDI ANSI X3T9.5Spec. |
| Core Diameter | 62.5·m ±2.5·m |
| Cladding Diameter | 125·m ±2.5·m |
| Attenuation | <3.5bB/km @ 850nm/km @ 1300nm |
| Bandwidth | >160Mhz/km @ 850nm/>500Mhz/ km1300nm. |
| Strength member | Aramid yarn |

## 4.4 Racks and Cable Management

All racks, in the server room and communication rooms shall be 19 inch racking products. In all cases the backbone cabling sub-system shall beterminated into rack mounted panels and presented as ST fiber connectors.

Cable management shall be provided with manageable patching facility. Horizontal management side rings shall provide an environment for ongoing maintenance of all future patching and enable move and changes to be handled easily.

The Contractor shall be responsible for fire-stopping all floor penetrations after installation.

The Contractor shall be responsible for all records and labeling of the rack mounted panels, both fiber and UTP/STP, to the convention provided by the Client.

## 4.5 Wiring Closet Sub-System

The wiring closet sub-system shall link all of the other sub-systems together and provide labeling hardware to identify each and every cable, connector and circuit. It also provides patch leads to facilitate the creation of each circuit at the distribution frames. The wiring closet sub-system shall consist ofoptical fiber and UTP termination and patching facilities, cable management and optical fiber and UTP patch leads.

### 4.5.1 Optical Fiber Management System (OFMS)

The OFMS shall provide a facility to efficiently terminate, protect,manage and present optical fibers to the user for utilization.

The OFMS shall be 19 inch rack mountable, 1U in height, fabricatedin mild steel and power coat finished.

The OFMS shall facilitate up to 24 fiber outlets in the one unit and shall be fully self-contained to securely terminate and manage the incoming fiber, providing the following features;

- Grommetted rear and side cable entry
- Cable strain relief posts.
- Internal fiber looping
- Fiber splice tray accommodation
- Slide off lid to facilitate access to splice tray
- Caution label affixed to warn of laser radiation.
- Integral labeling to identify ports, and configured according to EIA/TIA 568-A standard (AB/BA sequencing).
- Mechanical protection of patch lead attachment to OFMS.

The incoming optical fiber shall be directly terminated onto an MTRJ/VF-45 connector.

### 4.5.2 UTP/STP Cable Termination

The UTP/STP cable termination panels shall provide a facility to efficiently terminate all incoming UTP/STP cable, and present them to the user in a structured, manageable format on industry standard RJ 45 connectors.

Both horizontal and vertical UTP/STP cables shall be terminated onto RJ 45 patch panels to provide a uniform cross-connect field.

### 4.5.3 UTP Patch Panels

The modular / configurable patch panels shall be 19 inch rack mountable fabricated in steel powder coated and provide RJ 45 outlets at the front for patching and Insulation Displacement Contacts (IDC) at the rear for UTP/STP cable termination. The IDC shall be universal in configuration to accept all popular IDC punch down tools for rapid termination of cables.

All patch panels shall be UL verified to Category 5 UTP/ Category 6 STP criteria, and exhibit the following performance characteristics:

**Electrical Specification**

- DC Resistance - 20 milli ohms
- DC Resistance Imbalance - 2.9 milli ohms
- Insulation Resistance - >100 Mega ohms
- Delay Skew - <45 nanoseconds

**Mechanical**

| | | |
|---|---|---|
| • Jack Contact | - material | phosphor bronze |
| | - plating | 1.25•m gold over 2.5•m nickel |
| | - force | 100g minimal |
| | - plug retention | 13.5 kg |
| | - operating life | 750 cycles (min) |
| • IDC Block | - material | phosphor bronze 2x0.4 |
| | - wire accommodation | to 0.65mm solid |
| | - tool accommodation | KATT, 110 & LSA+ |
| | - operation life | 200 terminations (min) |
| | - gas tight IDC Cable termination | |

The UTP/STP patch panels shall be configured and terminated in the EIA preferred 568-B wiring sequence.

The UTP/STP patch panels shall have a high density RJ 45 outlets

for efficient utilization of space in the rack, but shall not be so closely spaced to make termination and patching cumbersome and unmanageable. The UTP/STP patch panels shall have a minimum density of 16 RJ 45 ports per Rack Unit and a maximum density of 24 RJ 45 ports per Rack Unit.

The UTP/STP patch panels shall provide integrated rear cable management for guiding UTP/STP cable to the IDC block. This management facility shall provide cable bend radius guides to ensure EIA/TIA 568-B minimum cable bend radius criteria (>8 times cable diameter) is not exceeded during installation: and hook and loop fastening tape to secure incoming UTP/STP cables without over compressing the cables, which could compromise the cable performance.

The UTP/STP patch panels shall provide flexible labeling facilities to uniquely identify each part. The labeling shall be removable to facilitate future reconfiguration of the identification scheme, if necessary. The labeling shall comprise of pre-printed cards or customized 13mm printed labels. The identification scheme shall be outlined in the Scope of Works.

### 4.5.4 Cable Management

Cable management facilities within each rack at the Wiring Closet Sub-system is a mandatory requirement.

The MDF and IDFs shall be arranged such that discrete horizontal and vertical channels are provided on the rack to route patch leads from source to destination.

The cable management channels shall be made up of power coated mild steel 19 inch rack mount panels with integrated ¯fingers‖ in which to route the patch leads. The horizontal channel formed by these fingers shall be enclosed by a snap-on ABS plastic cover at both ends of panel separate ABS plastic rings shall be mounted using the rack mount bolts of the panel to create a vertical ring run up the rack. These rings shall be sufficiently large enough to comfortablyaccommodate in excess of 50 patch leads, yet narrow enough not to overhang the width of the rack or obscure the horizontal ring run segment.

The cable management panels should be mounted on the patching facility between every two rows of RJ 45 ports. In this way, patch leads from every RJ 45 patch panels port are directed to the cable management panels above or below the outlet, so that at no time even when fully populated, outlets are obscured by patch leads. Such a layout shall ensure the patching facility, when cable management is properly utilized, does not go out of control and can be efficiently utilized for adds, moves and changes over the life of the Structured Cabling System.

The plastic rings shall be sufficiently large enough to comfortably accommodate in excess of fifty (50) patch leads at any time.

In view of the dynamic nature of the patching facility, the ¯fingers‖ of the cable management panels shall be made of mild steel and integral to the metal panel, so that excessive force on the patch leads do not deform the channel formed within the ¯fingers‖. The cable management panel shall be supplied with a snap on cover to discretely conceal the patch leads when the patching facility is static.

To facilitate effective patching during the life of the Structured Cabling System, the rack shall be laid out for minimal clutter and the shortest reasonable route for patch cords.

In a single rack installation, the patch panels terminating the horizontal cabling should be centrally located on the rack. Active equipment such as LAN hubs/switches accommodated in the rack should, be mounted above the horizontal cable patch panels. System patch panels or terminal based systems if utilized, should be mounted above the active equipment. The Optical Fiber management system shall be mounted above the system patch panels, which keeps the fiber patch leads separate from the UTP/STP patch leads.

Optical fiber patch leads shall be routed through the cable management facility, taking care not to mix these excessively with UTP patch leads.

### 4.5.5 Optical Fiber Patch Leads

All optical fiber patch leads shall comprise multimode 62.5/125•m FDDI performance graded index optical fiber with MTRJ/VF-45 fiber connectors terminated at each end.

The optical fiber patch leads shall comply with the following specifications:

- Connector
  - zirconia ceramic ferrule
  - per-radiussed and pre-polished ferrule
  - epoxy type fiber encapsulation
  - built-in strength member retention
  - color coded connector boots fitted to connectors on duplex patch leads. Oneconnector shall be fitted with a red boot,designated as the ¯transmit‖ fiber and a

corresponding red boot at the other end of the assembly. The other boot shall be black in color, similarly black at the corresponding other end.

- Dust caps shall be fitted on eachconnector at the assembly.

Cable
- Simplex or duplex multimode FDDI Performance graded index 62.5/12.5•m optical fiber.
- Strength member – aramid yam
- 900•m tight buffer diameter
- Orange PVC UL listed overall jacket (designating multimode fiber).

**Transmission Specifications**

- Insertion loss (connector) 0.3dB (mean)
- Attenuation (cable) 3.75 dB/km @ 850nm
  1.50 dB/km @ 1300nm

**Labeling**

- Port No. unique serial number and assembly length shall be printed on label, affixed at one end of the cable assembly, no more than 450mm from the end.

### 4.5.6 UTP/STP Patch Leads

UTP/STP patch leads shall provide the interconnection between horizontal and vertical cabling and active devices at the cross connect facilities. In view of the dynamic nature of patching over the life of the Structured Cabling System, only products with highest quality and reliability shall be supplied. No patch lead shall be manufactured, assembled or fabricated on site. All patch leads shall be factory terminated and tested, under controlled conditions.

The UTP/STP patch leads shall be supplied in the quantities, lengths and sheath colors outlined in the BOQ.

The UTP patch leads shall be manufactured from EnhancedCategory 6A / Category 6A STP (550 MHz), 4 pair stranded UTP/STPcable and terminated with Enhanced Category 6A RJ 45 plugs.

The UTP/STP patch leads shall comply to the following performance characteristics:

8-wire non-keyed RJ 45 socket.

**Mechanical**

| | | |
|---|---|---|
| • Jack Contact | - material | phosphor bronze |
| | - plating | 1.25um gold over 2.5um nickel |
| | - force | 100g minimal |
| | - plug retention | 13.5 kg |
| | - operating life | 750 cycles (min) |
| • IDC Block | - material | phosphor bronze |
| | - wire accommodation | 0.4 to 0.65mm |
| | - tool accommodation | KATT, 110 & LSA+ |
| | - operation life | 200 terminations (min) |
| | - gas tight IDC Cable termination | |

**Electrical**

- DC Resistance - 69 milli ohms
- DC Resistance Imbalance - 20 milli ohms
- Insulation Resistance - >100 Mega ohms
- Wiring Sequence - EIA preferred (568 A)

## 4.6 Horizontal Sub-system

The horizontal cabling sub-system is the concealed cabling from the communication room to the user location. In each case it shall consist of the media and the connecting hardware at each end to terminate the media. The floors of the building shall be served by an individual] horizontal sub-system.

The topology of the horizontal sub-system is star connected with each cable being a maximum of 90 meters. Where a horizontal sub-system cannot be established within the 90 meter limitation, a second IDF shall be established to install a second horizontal sub-system to meet the specification. The location of a second or subsequent IDF shall be to the Engineer's approval.

### 4.6.1 Category-6A UFTP Cable

The horizontal cabling shall be category 6A UFTP (550 MHz minimum) 4 pair cable,23 AWG, LSZH, delivered in 305m or 500m pull boxes and comply to the following specifications.

The cable shall be UL verified and Listed.

**Specifications**

- No. Pairs 4
- Conductor 23 AWG solid copper
- Insulation polyolefin
- Insulation Thickness 0.21mm
- External Sheath Flame RetardantPVC
  - Sheath Color Blue for Data / Grey forVoice
- Sheathed Cable diameter 5.0mm
- Operational Temperature range -20°C to 70°C

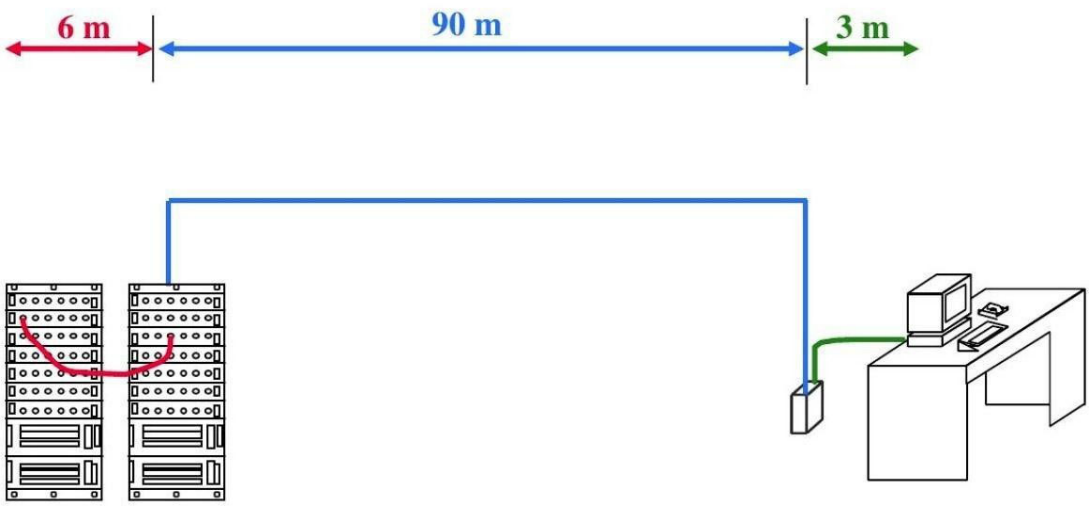
**Transmission Characteristics for Cat-6 STP Cables**

| Frequency (MHz) | ACR in dB | Maximum Attenuation dB/100m | NEXT db @ 100m |
|---|---|---|---|
| 1 | 98.2 | 2.1 | 66 |
| 10 | 94.7 | 6.0 | 59.3 |
| 16 | 93.2 | 7.6 | 56.2 |
| 20 | 92.4 | 8.5 | 54.8 |
| 31.25 | 90.4 | 10.8 | 51.9 |
| 62.5 | 82.4 | 15.5 | 47.4 |
| 100 | 77.7 | 19.9 | 44.3 |
| 250 | 62.3 | 33.00 | 38.3 |

All UFTP cabling shall be installed in already laid cable trunking/conduit. The Contractor shall make every effort to install the horizontal cabling sub-system in a concealed manner, but where that path is obstructed written prior approval shall be obtained from the Engineer prior to using surface ducting or conduit.

The horizontal cable shall be continuous run from the wiring closet to the work area outlet, free from taps, joints and splices. Cat 5 UTP cables shall be installed for voice and Cat 6A STP cable for data communication.

## *Horizontal Distances*




### 4.6.2 Category-6A Outlets

The horizontal cabling shall be terminated on RJ 45 outlets on British Standard flush mounting white plastic wall plate at the work areas of each floor. The outlets shall be Category-6A.

These outlets shall be configured as discrete units for each individual work area mounted on already installed flush steel back boxes. Surface mount wall plates are not permitted unless approved by the Engineer.

The RJ 45 outlet shall comply with the following specifications:

The RJ 45 outlets shall be mounted in a configurable multimedia outlet system to facilitate future upgrades to the configuration of the workstation. Where the wall plate is not populated, removable blanking modules shall be inserted.

The RJ 45 outlets shall be protected by a spring-loaded shutter, which will cover the outlet when not in use.

The RJ 45 outlet modules shall provide a labeling facility to identify each individual outlet. The label shall be printed with a high-contract,

high-visibility icon as listed in the specification and in the color specified. All labeling shall be integral to the manufacturers wall plate system. Third party labeling systems will not be accepted.

**Mechanical**

- 8 wire non keyed RJ 45 socket

| | | |
|---|---|---|
| • Jack Contact | - Material | phosphor bronze |
| | - plating | 1.25 um gold over 2.5 um nickel |
| | - force | 100g minimal |
| | - plug retention | 13.5 kg. |
| | - operating life | 750 cycles (min) |
| • IDC Block | - material | phosphor bronze |
| | - wire accommodation | 0.4mm to 0.65mm |
| | - tool accommodation | KATT, 110 & LSA+ |
| | - operating life | 200 terminations (min) |
| | - gas tight IDC Cable termination | |

**Electrical**

| | |
|---|---|
| • DC Resistance | 69 milli ohms |
| • DC Resistance Imbalance | 20 milli ohms |
| • Insulation Resistance | >100 Mega ohms |
| • Wiring Sequence | EIA preferred (568 B) |

**Approvals**

- UL Listed and verified to Category-6A (550 MHz)

### 4.6.3 Work Area Sub-system

The Work Area Sub-system shall consist of the connection between the user location wall plate and the terminal equipment. It shall provide leads and adopters as outlined in the BOQ.

The Contractor shall be responsible for the supply of all leads associated in the connection of terminal equipment to the user location wall plate. The lengths, colors and quantities of each to be supplied are outlined in the BOQ.

All shall be Category-6A UFTP and any adaptor shall be installed as close to the terminal as possible.

All Category-6A UFTP leads shall be factory manufactured andtested.

The Work Area UFTP lead shall comply with the followingspecifications:

**Mechanical**

- 4 pair UTP/STP leads terminated on 8 wire non-keyed RJ 45plugs

| | | | |
|---|---|---|---|
| • Cable | - | conductor material | 0.5mm stranded copper |
| | - | insulation | polyolefin |
| | - | sheath | PVC |
| • Plug | - | housing material | ABC plastic |
| | - | contact material for | phosphor bronze configured stranded cable. |
| | - | contact plating nickel | 1.25 µm gold over 2.5 µm |
| | - | cable termination Contact. | Insulation Displacement |
| | - | cable retention | self crimping |

**Electrical**

| | |
|---|---|
| • Characteristic Impedance | 100 ohms +15 ohms |
| • DC Resistance | 5% |
| • Wiring sequence | EIA preferred (568 B) |

**Approvals**

- UL Listed and verified to Category-6A (550 MHz)

## 4.7 Disconnection Module

Disconnection module shall have a two piece contacts normally closed, incorporating a disconnection facility. It shall have provision for test andmonitoring access and over voltage protection.

## 4.8 Micro Ducts

Micro ducts of 5 mm dia or 8 mm dia as shown on drawings shall be provided for the up gradation of the structured cabling. Micro ducts shall be tubes of co-extrusion construction, comprising an inner ‗blow able' and outer layer of low smoke and flume flame retardant material. Fiber shall be blown up to 500m in 5 mm duct and 1000 m in 8 mm duct. Wall outlet shall be provided with end caps/plugs and blanks to seal micro duct. Micro duct shall beprovided from outlet up to the trunking.

### 4.9 Multimedia Outlet System

Multimedia Outlet System shall be provided to install UTP/STP and Fiber media, allowing upto 4 ports to be installed. At each multimedia outlet provision shall be provided to install Fiber media in future. The modular multimedia shall consist of fascia, bezel and module. Bezel shall be provided with mounting screws, clear label holder and color matched screw covers. Wall plates shall be provided with telecom icons (phone, data, fax, etc.).

### 4.10 Cabinet and Frame

Cabinet and Frame shall accommodate 19‖ patch panel and glass or active equipment side panels ventilation slots and cable management. Frame shall have cable management arms.

## 5.0 INSTALLATION

All cable installations shall be completed according to the local regulatory board andconform to EIA/TIA 568-A and shall comply with the following criteria:

### 5.1 Optical Fiber Cable

Cables shall be installed in powder coated steel trunking with over including all accessories, supports, etc. as per site requirements, care shall be taken to ensure minimum bending radius requirements as per manufacturer‘s recommendations for optic fiber cable are maintained.

### 5.2 UTP Cable Installation

Cables shall be installed in already laid conduit/steel cable trunking (within suspended ceilings) suitably anchored to the building structure, and in conduit in floor and partitions (concealed). Cables shall be secured every 600mm using hook and loop fastening ties. Due care shall be taken to not over tighten ties and place undue strain on the cabling infrastructure.

Cables shall be bundled to a maximum of 24 cables and each bundle individually supported within the cable trunking.

Bend radius shall be limited to 10 times the cable diameter.

During the installation of a cable (maximum 90 meters) the pull distance should not exceed 30 meters at any one time.

## 6.0 TESTING AND COMMISSIONING

The following tests shall be carried out and the results shall be documented and maintained to form part of the ―AS BUILT‖ drawings.

1. Test all of the UTP/STP copper cable installation for termination and twisted pair integrity, including continuity, polarity, pin-assignment and color codes

2. Perform visual inspections to ensure that each pair of wires remain twisted as close as possible to the termination point, to maintain the impedance and minimize attenuation losses.

3. Test that the UTP/STP cable pairs comply with the Specification using measuring device for Near End Cross-talk and Signal Attenuation complying with EIA/TIA 568-A.

4. Test each termination Optical Fiber in both directions, recording all results of the calibrated optical power. Make sure in all cases that measurements are within those provided in the specification.

The documentation required at the completion of the installation phases shall contain all of the following information, together with any other information the installer has acquired during the installation.

1. ―As-Built‖ documentation, showing total cabling and connection installed, utilizing floor space plans and cable record sheets. This documentation shall show all cables and outlets incorporating the full numbering and marking convention supplied.

2. All test results and certification information, identified by cable, connection and numbering convention, necessary for all Optical Fiber and copper cables.

All components of the LAN Cabling System should be sourced from one manufacturer to ensure minimal impedance mismatch and best possible NEXT performance and to guarantee the Category-6A performance from end to end.

The Structured Cabling System should operate without introducing or being affected by electromagnetic radiation from other sources. Maintaining segregation from other services or screening are to be ensured to achieve acceptable immunity.

## 7.0 MEASUREMENT AND PAYMENT

### 7.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the TenderDrawings related to the item.

### 7.2 Conduits

7.2.1 **Measurement**: Measurement shall be made for the number of running foot for conduits acceptably supplied and installed by the Contractor.

7.2.2 **Payment**: Payment shall be made for the number of running foot of conduit measured as provided above at the Contract unit price and shall constitute full compensation for supplying, installing and completion of the laying of the conduits including jointing materialsand accessories, cutting chasing of civil works, excavation and backfilling of ground for underground PVC conduits, painting, tagging,etc., as applicable for each type of work.

### 7.3 Backbone Cabling

7.3.1 **Measurement**: Measurement will be made for backbone cabling as a complete job acceptably supplied and installed by the Contractor.

7.3.2 **Payment**: Payment will be made for the complete job of backbone cabling at the Contract unit price and shall constitute full compensation for supply, installing, testing and commissioning of the optical fiber cable including fiber management system and all accessories.

### 7.4 RJ 45 Outlet

7.4.1 **Measurement**: Measurement shall be made for each RJ 45 outlet acceptably supplied and installed outlet box by the Contractor as a complete unit.

7.4.2 **Payment**: Payment shall be made for number of units measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing and completion of the RJ 45 outlet including all civil works and other accessories.

## 7.5 Patch Panels

**7.5.1 Measurement**: Measurement shall be made for each patch panel acceptably supplied and installed by the Contractor as a complete unit.

**7.5.2 Payment**: Payment shall be made for number of unit measured as provided above at the contract unit prices each and shall constitute full compensation for supplying, installing and completion of the patch panel box including all civil works and other accessories.

## 7.6 Cabling RJ 45 Outlets/Patch Panels

**7.6.1 Measurement**: Measurement shall be made for the total number of cabling from each RJ-45 outlet relevant rack acceptably carried out by the Contractor as complete unit.

**7.6.2 Payment**: Payment shall be made for the total no. of units measured, as provided above at the Contract unit prices each and shall constitute for supplying, installing connecting, testing, commissioning and completion of the cabling between RJ 45 outlet, and patch panel and between patch panels including required pair of multi-core data cable and appropriate size conduit and all accessories.

## 7.7 Cabinet and Frames

**7.7.1 Measurement:** Measurement shall be made for the each Cabinet and Frame, acceptably supplied and installed by the contractor as a Complete Unit.

**7.7.2 Payment:** Payment shall be made for the number of unit measured as provided above at the Contract Unit Price and shall constitute full compensation for supply, installing and commissioning of the Cabinet and Frames including all accessories.

## SURVEILLANCE AND COMMUNICATION NETWORK WORKSCHEDULE ITEM

### 1. CCTV

**Camera General Specifications:**

Compression options H.265, H.265+, H.264+, H.264, min 120dB Wide Dynamic Range and Day/Night, 3D Digital Noise Reduction, IR range: min 30m, IP66 or above, IK10, min illumination 0.05 lux and 0 lux with IR on, outdoor/indoor, ONVIF and IP based.

**1.1. Surveillance Dome camera:**

2 MP, 1/2.8" imager size, 2.8 mm lens, Dome type

**1.2. Surveillance Bullet camera for indoor:**

2 MP, 1/2.8" imager size, 2.8 mm lens, Bullet type

**1.3. Surveillance Bullet camera for external side:**

6 MP, 1/2.9" to 1/3" imager size, 12 mm lens, Bullet type

**1.4. Surveillance PTV camera for surrounding area of building:**

2 MP, 1/2.9" to 1/3" imager size, PTZ type

**1.5. Surveillance ANPR camera for Vehicles entry area in building:**

6 MP, 1/2.9" to 1/3" imager size.

**1.6. Surveillance Fish-Eye camera:**

3 MP, 1/2.8" to 1/3" imager size, 2mm @F2.4, angle of view:
360°, fisheye

**1.7. NVR for local video storage CCTV room:**

32 channels, 320 Mbps input rate, 4 channel @4K display, 2 HDMI, VGA, 64 TB storage, 2xGbE ports, AC 180-260 V Power supply, H.265+, H.265, H.264, MJPEG compression, people counting, heat map, face detection, 1 e-sata, 2 HDMI (up to 3840 x 2160 , Different Source), 1 VGA

**1.8. Storage system for surveillance video:**

Max 512 channel. Hybrid Platform with option for SSD and SAS Drives. Multi chasis system with Minimum 120,000 IOPS and 1.5 GB/s bandwidth per chasis. multiple

nodes per Chasis. Intel Xeon CPU per node, 2x10 GE per node, dual redundant hot swappable power supply with PFC with 180-265VAC Input Voltage Total storage capacity of 500TeraByte Complete with racks, cabling and all accessories and relevant software licenses.

### 1.9. UPS for storage system:

10 KVA, Online double conversion, modular, hot swappable, input Voltage range 150-264V, input frequency 35-70 Hz, Output frequency 50Hz, upto 96% efficiency, THD <1.5%, PF at 100% load >= 98%.

### 1.10. UPS for NVR in CCTV room:

1 KVA, true online with 15 min back up time

### 1.11. Video Management Server:

Video Management Rack Server. Chassis with up to 8 x 2.5" SAS/SATA Hard Drives for 1CPU,Intel® Xeon® Silver 4108 1.8G, 8C/16T, 9.6GT/s, 11M Cache, Turbo, HT (85W) DDR4-2400, 16x2GB RDIMM, 2666MT/s, Dual Rank, 240GB SSD SATA Mix Use 6Gbps 512e 2.5in Hot-plug Drive, 2TB 7.2K RPM SATA 6Gbps 512n 2.5in Hot- plug Hard Drive, Windows Server® 2016,Standard,16CORE,Factory Inst, No MED, NO CAL with Media Kit, Dual, Hot-plug, Redundant Power Supply (1+1), 495W

### 1.12. Video Management software scalable and modular:

Extensible with plugins for overlays and ANPR, capable of managing min 500 cameras, with clustering support for redundancy, with media gateway, operations management, with options to integrate with third party storage solutions with investigate options

## 2. OPTICAL FIBER CABLING

### 2.1. Supply, Pulling, Testing & Commissioning, of Optical Fiber Cable:

24-Core Single Mode ITU-T (G.655), support 10 Gig, Armored, loose-tube, duct as per specifications with all necessary accessories as per requirement.

### 2.2. Supply, Pulling, Testing & Commissioning of Optical Fiber Cable:

6-Core Single Mode ITU-T (G.655), support 10 G, Armored, loose-tube, duct as per specifications with all necessary accessories as per requirement. (For internal network).

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### 2.3. Fiber Patch Panel 48 Port:

Supply and Install Fiber ODF-48-Port, Splice 1U, 24-Port, Rack Mount, Fiber Patch Panel Loaded with SCadapters, SC Pigtails, fiber adapter plate and Splice trays with all other accessories as per specifications and requirement.

### 2.4. Optical Patch Cord SC to LC:

Supply and Install Optical Patch Cord SC to LC 3 meter or as per required LC to SC, 9/125, Single mode, Simplex/Duplex Patch Cables.

### 2.5. Media Converter 02-port:

Supply and Fixing of PoE Media Converter 02-port: (Manageable), 10/100/1000Base-T to 100/1000Base-X Fiber, as per specifications and requirement for CCTV Camera.

### 2.6. Media Converter 24-port Chassis:

Supply and Fixing of Media Converter 24-port Chassis, 10/100/1000Base-T to 100/1000Base-X Fiber, as per specifications and requirement for CCTV Camera.

### 2.7. Fiber Optic Splice Closure:

Supply & Installation of 24-Core Horizontal Fiber Optic Splice Closure (Splicing as per site requirement) with 2 in-out cable ports, Water proof (protection grade is IP 68), suitable for Manhole (with all other wall mounting accessories). The closure can be opened Supply, Installation, Testing & Commissioning of SFP 10G (10/40Km).

## 3. NETWORK EQUIPMENT'S

### 3.1 Core Switch 24 port (Manageable):

Supply and Installation of Core Switch 24 port (Manageable) 24 SFP+ 10G ports and at least four QSFP ports. At least 2.56 Tbps throughput. With separate Control and Data Planes. Dual hot-swappable AC or DC power supplies to provide 1+1 redundancy.

Hot-swappable fan trays. Support for network virtualization, LAN and SAN

### 3.2 Ethernet Switch 48-port:

Supply and Installation of Ethernet Switch 48-port L3 Fully Manageable, nonblocking architecture, Switch having 24x10/100/1000Base-T ports with 2 SFP+ 10 GB Uplink ports IRack-mountable, min 92 Gbps switching capacity, 16k MAC Addresses, 11. Support for Control Plane Prioritization (CPP) with dynamic link failover, support SNMP, SSH and SSL for secure management, with AMF MIB and SNMP traps;

**3.3** **PoE Switch with 16 full power PoE ports:**
Supply and Installation of PoE Switch with 16 full power
PoE ports Minimum PoE budget of 320 Watts, 10/100/1000 Mbps ports with 2xcombo SFP Slots loaded, Rack-mountable, or as per requirement.

**3.4** **42U Rack:**
Supply and Fixing of *42U Rack* floor Standing, with lockable glass door, fine powder coated with fans and trays, must be imported with authorized distributor presence, must have rack mount PDU, in the package. with all accessories.

**3.5** **Access point Dual band:**
Supply and install Dual Band Access Points Ceiling mount/Wall Mount 2.5 GHz and5 GHz for wireless devices

**3.6** **9U Rack:**
Supply and Fixing of 9U Rack, wall mounted, with lockable glass door, fine powder coated with fans and trays, must be imported with authorized distributor presence, must have rack mount PDU, in the package. with all accessories.

**3.7** **Telco Rack 42U:**
Supply and Fixing of Telco Rack 42UFloor Standing, with lockable glass door, fine powder coated with fans and trays, must be imported with authorized distributor presence, must have rack mount PDU, in the package. with all accessories.

## 4. STRUCTURED CABLING

### 4.1. CAT6A UTP Ethernet Cable:

Supplying and laying of CAT6A UTP Ethernet Cable 23AWG (0.57 mm), CM rated and UL listed, (Blue Color), NSI,TIA,EIA, ISO Compliance-1G Support for 100meter and 10G support for 55 meter cables through PVC conduit / cable tray as shown in the drawing or otherwise as directed by the consultant, from server to SWITCH/ROUTER to Computer Data Sockets, as required to be completed in all respect.

### 4.2. Data and Voice outlet:

Supply and installation of Simplex data and Voice outlet on wall / furniture / partition with make Computer data socket with Single I/O (RJ 45) CAT6A, face plate and back box, as shown in the drawing or as per requirement, with chase cutting, mending good etc. as required completed in all respect.

### 4.3. Duplex data and Voice outlet:

Supply and installation of Duplex data and Voice outlet on wall / furniture / partition with make Computer data socket with Dual I/O (RJ 45) CAT6A, face plate and back box, as shown in the drawing or as per requirement, with chase cutting, mending good etc. as required completed in all respect.

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### 4.4. Patch Panel CAT6A 48 Port:

Supply and installation of Patch Panel CAT6A 48 Port:
(fully loaded) with CAT6A I/O, with front/rear cable management ANSI, TIA, EIA, ISO Compliance Flame retardant -Must be UL Listed and should have side covers on cage nuts.

### 4.5. Patch Panel CAT6A 24 Port:

Supply and installation of Patch Panel CAT6A 24 Port: (fully loaded) with CAT6A I/O, with front/rear cable management ANSI, TIA, EIA, ISO Compliance Flame retardant -Must be UL.

Listed and should have side covers on cage nuts.

### 4.6. Patch cord CAT6(1 meter):

Supply of Patch cord CAT6 UTP (1 meter) Machine punched, Stranded, ANSI,TIA,EIA, ISO Compliance with Gold over nickel plated contacts in Connector, must have anti snag mechanism- Must be UL Listed, from core switch
to LAN Patch panel.

### 4.7. Patch cord CAT6 (3 meter):

Supply of Patch cord CAT6 UTP (3 meter) Machine punched, Stranded, ANSI,TIA,EIA, ISO Compliance with Gold over nickel plated contacts in Connector, must have anti snag mechanism- Must be UL Listed, from wall outlet
to devices.

### 4.8. Termination and Labeling of CAT 6A:

UTP cable on both end.

### 4.9. Testing and commissioning of copper nodes:

With Fluke Network devices. Including submission of detailed test reports.

## 5. CONDUITING AND DATA & SOCKETS

### 5.1. Floor Outlet Box:

Providing, fixing, testing & commissioning of waterproof floor outlet box (L259mm x W203mm x H84mm) Stainless steel box and Flanged Frame (cover) (L283mm x W225mm x H3mm) fixing to the conduit with lock, installed between every conduit joint, bends and access area as per drawing, complete in all respect.

5.2. PVC Conduit:

Supply & Installation of following PVC Conduit as race ways with all accessories recessed/ surface on wall / column /along roof/under floor for Ethernet cable. As per relevant specification, complete in all respect.

25 mm dia

Pvc Pipe 50

mm dia Pvc

Pipe

## 6. ACCESS CONTROL

Supply and install Access control for security gates as per SBP requirements. As per relevant specification, complete in all respect.

## 7. LED TV FOR MONITORING:

Supply and install LED TV 55" as per drawings and As per relevant specification,complete in all respect.