सत्यमेव जयते

भारत सरकार
GOVERNMENT OF INDIA

परमाणु ऊर्जा विभाग
DEPARTMENT OF ATOMIC ENERGY

निर्माण, सेवा एवं संपदा प्रबंधन निदेशालय
DIRECTORATE OF CONSTRUCTION, SERVICES AND ESTATE MANAGEMENT



यांत्रिक कार्यों के विनिर्देश

SPECIFICATION FOR MECHANICAL WORKS

2024

विक्रम साराभाई भवन ,अणुशक्तिनगर ,मुंबई-४०००९४
Vikram Sarabhai Bhavan, Anushaktinagar, Mumbai - 400 094



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के. महापात्रा
K. MAHAPATRA

भारत सरकार
Government of India

उत्कृष्ट वैज्ञानिक एवं निदेशक
निर्माण, सेवा और संपदा प्रबंध निदेशालय
Outstanding Scientist & Director
Directorate of Construction,
Services & Estate Management

FOREWORD

The DCSEM Specification for Mechanical Works being published by DCSEM is very comprehensive and useful in execution of Mechanical Works. This specification serves as guideline to Engineers and Contractors for specification of Materials, Execution of Works and Mode of Measurements.

The Specification for Mechanical works has been revised with addition of specification of items as per requirements and current practices.

I wish to place on record, the effective involvement and the efforts of dedicated team of Mechanical Engineers led by Shri Shravan Tanjore, SO/E, Shri Raushan Kumar, SO/E, Shri Anil Kumar, SO/E & all other Senior Engineers of this Directorate for their valuable inputs in preparing and finalizing this Specifications for Mechanical Works.

My special thanks to Shri Sameer Jadhav, Head (ED), Shri D.Sengupta, Head (MD), Shri A.S.Yadav, Chief Engineer (ESG), Shri. A.K.Jana, Chief Engineer (C1/CQD) for their valuable suggestions from time to time.

I am sure that this Specification will be useful for Mechanical Works to all concerned units engaged in Building Works in DAE, in general and DCSEM in particular.

29.02.2024
(K. Mahapatra)

Place: Mumbai
Date: 29th February, 2024.

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PREFACE

1.) The Specifications for individual Mechanical works are compiled in the form of comprehensive DCSEM Specifications for Mechanical Works 2024 (Part-A HVAC Works & Part-B Firefighting Works)

2.) The specifications of many items have been updated and improved by making them more comprehensive. Many new items using new materials and latest technology have also been added.

3.) The specifications for Mechanical works-2024 incorporates following new features:

3.1) **List of Indian Standard Codes:** Included Relevant IS Codes.

3.2) **Screw and Centrifugal Chillers:** Air-cooled & Water-cooled (as applicable).

3.3) **Automatic sprinkler system:** Specifications and installation guides added.

3.4) **Sub-Station:** Compact sub-station specifications added.

3.5) **Fire Detection System:** Fire alarm & public address system have been added.

3.6) **Installation procedures:** This has been included.

3.7) **Mode of Measurement:** This has been included.

3.8) Recommended / preferred manufacturer list for materials is modified by deleting names of discontinued makes and by incorporating of new makes.

4.) Due care has been taken to prepare DCSEM Specifications for Mechanical works 2024 as correctly as possible. It is, however, possible that some errors might have crept-in inadvertently. In case any error or omission is noticed, it may be brought to the notice of the **Head (MD), DCSEM, V. S. Bhavan, Anushaktinagar, Mumbai-400094.**

Suggestions for improvement are always welcome.

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Part-A HVAC Works

Part 1- Technical Specifications for Chilled Water Based AC System

Chapter 1
GENERAL CONDITIONS

1) SCOPE:

The scope under general conditions covers the design, fabrication, testing in factory, packing for transport to site, transport, loading and unloading, handling of equipment at site, fabrication at site, installation, testing at site and commissioning into service and handing over the HVAC system to the Department along with all the documents like Technical Specifications, Test Reports, Commissioning Report, as Built Drawings etc.

2) RELATED DOCUMENTS

These Specifications shall be read in conjunction with the other tender documents like the general conditions of contract, schedule of work, drawings and other documents connected with the work. In the event of any discrepancy between the various tender documents and drawings, then, the schedule of quantities shall prevail.

3) SITE INFORMATION

The contractor/ (also addressed as agency/tenderer) should, in his own interest, visit the site and familiarize himself with the site conditions before tendering. For any clarification, contractor may discuss with the Engineer-in-Charge.

4) CONFORMITY WITH STATUTORY ACTS, RULES, ORDERS, STANDARDS AND CODES

(i) The design, manufacture and performance of equipment should comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The system and all the equipment should also conform to the requirement of the latest editions of applicable IS/ B.S Standards and CFO clearances if required. The contractor should refer the relevant sections of this specification for equipment standards and codes. Nothing in this specification should be construed to relieve the contractor of his responsibility.

(ii) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2010, NEC 2011 amended to date. They shall also conform to DCSEM's General Specifications for Electrical Works, Part-I (Internal)-2013, Part-II (External)- 1994, Part IV (Sub-station) 2013 and Part-VII (D G Sets)-2013 amended to date.

5) SAFETY CODES AND LABOUR REGULATIONS

(i) In respect of all labour employed directly or indirectly on the work for the performance of the contractor's part of work, the contractor at it's own expense, will arrange for the safety provisions as per the statutory provisions including "Safety, Health and Environment Handbook 2019" published by CPWD, B.I.S recommendations, Factory Act, Workman's Compensation Act, CPWD Code and instructions issued from time to time. Failure to provide such safety

requirements would make the contractor liable for penalty to be decided by Engineer-in-charge. In addition, the Engineer-in- charge, shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost incurred thereon from the contractor.

(ii) The contractor shall provide necessary barriers, warning signals and other safety measures while laying pipelines, cables etc. or wherever necessary so as to avoid accident. He shall also indemnify DCSEM against claims for compensation arising out of negligence in this respect. Contractor shall be liable, in accordance with the Indian Law and Regulations, for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage incurred or claims arising therefrom during the execution of work. The contractor shall also provide all insurance including third party insurance as may be necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

6) WORKS TO BE DONE BY THE CONTRACTOR

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in the tendered cost- whether specifically indicated in the Schedule of Work or not: -

i) Foundations for equipment including foundation bolts and vibration isolation spring/pads,
ii) Suspenders, brackets and floor/wall supports for suspending/supporting pipes.
iii) Suspenders and/or cable trays for laying the cables,
iv) Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, including necessary base treatment and supports.
v) Sealing of all floor slab/wall openings provided by the Department or made by the contractor for pipes and cables, from fire safety point of view, after laying of the same.
vi) Space for accommodating all the equipment and components involved in the work.
vii) Power supply, Water supply and Drain points for all tender related works.
viii) Making openings in the walls/floors/slabs or modification in the existing openings wherever provided for carrying pipe line, cables etc.
ix) All electrical works including cable/wires, earthing etc. beyond power supply made available by the department.
x) Making good all damages caused to the structure during installation and restoring the same to their original finish.

7) COMPLETENESS OF THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK

i) **Completeness of the tender**:-
All sundry equipment, fittings, assemblies, accessories, hardware items, foundation bolts, supports, termination lugs for electrical connections, cable glands, junction boxes and all other items which are useful and necessary for proper assembly and efficient working of the various equipment and components of the work shall be deemed to have been included in the tender, irrespective of the fact whether such items are specifically mentioned in the tender or not.

ii) **Submission of phase programme**: -
Within fifteen days from the date of receipt of the letter of award, the successful contractor shall submit his phase programme for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in-Charge. This programme shall be framed keeping in view the building progress and the Milestones fixed in the General Conditions of Contract. Items like piping etc. that directly affect the building progress shall be given priority. Hose pipes, branch pipes, first aid hose reel pipes may be supplied just before commissioning the system.

iii) **Submission of Drawings**: -
The contractor shall submit the drawings to the Engineer-in-Charge for approval before start of work.

iv) **Commencement of work**: -
The contractor shall commence work as soon as the drawings submitted by him are approved either in full or in part as the case may be.

8) CO-ORDINATION WITH OTHER AGENCIES

The contractor shall co-ordinate with all other agencies involved at the site of work so that the work of other agencies is not hampered due to delay in his work. Piping, cabling or any other work, which directly affect the progress of work of other agencies, shall be given priority.

9) MATERIALS AND WORKMANSHIP:

All materials used, should conform to the requirements of materials specified in this specification and preferred makes of materials. Where material requirements are not specified they should conform to the applicable standards and codes approved by the Department. All materials should be new and free from defects and first class in all respects. Parts should be free from flaws and objectionable imperfections and they should be fabricated / machined true in a workman like manner. No deviations from the specified materials are permissible. Wherever materials are not specifically called out, they should be properly selected by the contractor to the best standards for the particular application and with the prior approval of the Engineer in Charge.

10) TENDER DRAWINGS:

(a) Drawings have been prepared by the Department showing the locations & system equipment layout & schematic diagram for the HVAC low side system.

(b) The drawings provided here are basic conceptual only. Bidder shall estimate the buildings cooling & heating loads, prepare the working drawings and shall submit all calculations to the department with selection charts including drawings for approval before procurement of equipment. The entire system design guarantee & achieving the indoor conditions will be whole responsibility of the Bidder.

(c) The equipment layout, pipe work as shown in the drawings represent a feasible scheme based on space available and equipment necessary the contractor should rearrange in the space allocated subject to the approval by the Engineer-in-charge.

(d) These drawings are not meant as working drawings. The contractor should prepare detailed working drawings and get them approved by the Department before starting the work. After completion of work, the contractor should have to submit “As built drawings” minimum six copies each along with soft copy of drawings which will be kept in department for further reference.

(e) The following shop drawings shall be prepared by the AC contractor for approval –

i. Chiller Plant Layout plan and Sections.

ii. High Side System Schematic (Including Chillers, Pumps, Cooling Towers, Piping etc.)

iii. Air Flow diagrams.

iv. AHU Room Layout plans and sections.

v. Low Side System Schematic (Including AHUs, Dampers, Piping, etc).

vi. Plan & Sections of Chilled water pipe and hot water pipe routing and their distribution to various AHUs.

vii. Duct layout plans of all floors including AHU rooms.

viii. Split AC system Layout Plan & Sections.

ix. Foundation details for all the equipment.

x. CPM & BMS System Architectures as per approved I/O Summary.

xi. Kitchen ventilation system layout plan and sections.

xii. Any other shop drawings necessary for the project.

(f) All shop drawings shall be prepared by the successful AC bidder after examining the Architectural & AC drawings & site conditions.

(g) The tentative layout plans enclosed with the tender documents are for guidance purposes only. Accordingly, contractor shall prepare shop

drawing and submit the same to the Department for approval. Work shall be strictly carried out as per the approved drawing.

(h) Where the drawings, specifications and schedule of quantities conflict, the schedule of quantities shall prevail. The instruction of Department / EIC shall be final & binding wherever clarity is lacking and it has not been sought by the contractor in the pre-bid clarification stage.

The Contractor shall point out all deviations from the drawings and specifications in their offer and shall specifically confirm works not included in their scope before opening of the financial bid. Nothing extra shall be payable on any account thereafter.

11) INSTRUCTIONS:

The contractor's proposal must include everything required to make a complete working of the system with all statutory approval whether specifically shown and specified or not including all labour and material, transportation etc. necessary for the complete installation of everything described and provided for a complete system which is ready for Department's use.

It shall be the responsibility of contractor to check the suitability & site constrains for installing the system at site. Any apparatus, appliance material and labour which may be necessary to complete the work in accordance with the intent or purpose of these specifications and as instructed by Department, the execution of the project shall be furnished by the contractor without extra cost irrespective of specifically specified in and / or shown on the drawings, or not.

The work shall be done in conformity to the specifications, accompanying drawings and with the requirement of the general, architectural and structural plans & other regulatory & statutory bodies including CFO, if required.

12) INSPECTION AND TESTING (GENERAL):

a) The contractor shall perform all tests and inspection necessary to ensure that the material and workmanship conform to the requirements of the contract including fabrication drawings approved by the Department or their authorized representative.

i. The contractor shall perform all tests and inspection necessary to ensure that the material and workmanship conform to the requirements of the contract including fabrication drawings approved by the Department or their authorized representative.

ii. The Department or their authorized representative shall have access to the contractor's or sub-contractor's works at all reasonable time to determine compliance with the provisions of this specification and /or to witness the contractor's inspection and tests.

iii. All tests covered by this specification shall be subject to inspection and approval by the Department.

iv. The contractor shall maintain records of all inspection works carried out in his works or in his sub-contractor's works. Copies of such records shall be made available to the department upon request and shall become the property of the Department. A procedure for the repair of defects shall be submitted to the Department for approval, prior to any repair modifications being made. If the previous quality test and inspection are

impaired by the subsequent repairs, the work shall be re-inspected and re-tested to the satisfaction of the Purchaser or his authorized representative. Equipment found unsatisfactory as to workmanship or material shall be removed by the contractor and replaced to the satisfaction of Department at no extra cost.

v. All materials of components, castings, piping, instruments etc. shall be tested & inspected in the presence of Department or their authorized representative at the manufacturer's factory. Test certificates of all imported components shall be made available for approval of the Department.

vi. No item/equipment mentioned in the schedule shall be shipped to site unless it is inspected, tested and certified for delivery by the Department or it's representative from the manufacturer's factory. All testing shall be as per latest additions of IS, B.S. & other applicable standards.

vii. Final acceptance will be after the equipment is installed and tested at site to give satisfactory performance.

viii. The Contractor shall provide the Department's Inspectors office facilities, necessary equipment and tooling instruments, drawings and personnel etc. required for inspection of the work.

b) Strict measures of quality control shall be exercised throughout the work. Static and dynamic balancing of all rotating parts shall be conducted in the presence of the Department or their authorized representative.

c) The contractor shall submit the following documents before acceptance.

i. All the tests observations & calculation.
ii. All the operation & maintenance manuals.
iii. Leaflet & literature
iv. Test Certificate
v. Guarantee Certificate
vi. Person to be contacted during Guarantee period.

13) TEST AT SITE:

a) During site fabrication of the pipes, they shall be inspected before they are positioned. After assembly, the system shall be checked for leakage, vibration and noise.

b) After the complete installation of the system with all accessories installed at site, these shall be tested as per applicable codes (unless otherwise specified) to check and access their functional performance. The test to be conducted at site in the presence of the Department's representative, shall include but not be limited to the following:

i. To check capability to deliver rated capacity and power consumption and performance factor after the installations of entire piping, ducting, equipment etc.
ii. To check capability of piping systems to deliver rated capacities after the installation of the valves & entire piping networks along with required capacities.

iii. To check capability of air handling systems to deliver rated capacities after the installation of the various dampers, diffusers etc. along with required capacities.
iv. To check proper, continuous and reliable operation of the whole system, including all equipment & all the controls regulating the equipment, for a period of minimum seventy-two (72) hours, after the complete installation of system.
v. Leak testing of the pipe work, fittings, connections etc. as applicable.
vi. Leak testing of the duct work, fittings, connections etc. as applicable.
vii. To check noise and vibrations etc.
viii. Any other tests as required to check compliance with specification and system requirements by statutory bodies & CFO & any other local authority for these systems in services.

c) **.** All required instruments consumables & services for the above tests shall be provided by the contractor.

14) SPARES AND TOOLS:

i. **. Spares:**
The contractor shall offer a complete list of recommended spare parts for the equipment supplied along with the item wise costs for the three years of satisfactory maintenance of the System.

ii. Tools:
All special tools required for operation and maintenance of the system shall be supplied by the contractor at agreed cost.

15) GUARANTEES:

i. **Equipment Guarantee:**
The contractor shall guarantee the trouble free & efficient performance of the system's design and capacity for one-year period (excluding shut down period due to fault). Date of acceptance will be treated as beginning of the guarantee period. Contractor will have to attend all the faults and replace all material (including consumables) free of cost during guarantee period. Major equipment parts will have to be guaranteed for further one year, from the date of replacement. Any leakage of lubricants due to defective manufacturing or bad workmanship shall also be made good by the contractor at free of charge.

ii. The contractor shall further guarantee that the system for optimum operation, the power consumption shall not exceed under any operating conditions of the value specified in the Technical Data Sheets.

16) QUALITY SURVELLIANCE & PROGRESS REPORTS:

Quality surveillance relating to all aspects of the contract will be carried out by the Department or their authorized representative for which the contractor or his approved sub-contractor shall:

a) Allow access at all reasonable time for inspection of manufacture, assembly, testing.

(i) The premises in which the work is being carried out.
(ii) Shall provide the drawing and /or tooling involved.
(iii) Shall provide the gauges, instruments testing equipment etc. required for inspection work.

b) Produce an inspection plan to the satisfaction of the Department's Representative and notify him when check points on the plan are imminent to enable his representative to be present, if he desires.
c) Inspection and tests shall be carried out as per the requirements of latest I.S. & details given in specifications of the tender document. Cost of the inspection will be borne by the contractor.
d) Parts found unsatisfactory, due to substandard workmanship or materials quality shall be removed by the contractor and replaced in a satisfactory manner acceptable to the department's representative. Any modification of inspection procedure or acceptance of the work by the department's representative does not relieve the contractor from the responsibility of supply equipment in accordance with the requirements covered by the tender documents.
e) The contractor shall submit two copies of monthly progress report on the manufacture, assembly, delivery of all equipment covered by these tender documents in the contractor work. Also, contractor shall submit two copies of monthly progress reports for the site work execution.
Delivery must not take place until the Department has been notified and written release of the equipment obtained. All materials shall confirm to the standards specification specified in the specification and technical requirements. Proof in the form of certified test reports that the required test has been carried out will be acceptable if prior permission is obtained from Department's Representative and he had granted such permission, but if those are not available then the tests shall be performed by the contractor at his own expense in the presence of Department or their authorized representative.
f) No inspection & clearance either in verbal or written shall relieve contractor of his responsibility & guarantee.

17) DELIVERY AND FABRICATION SCHEDULE:

Delivery and Fabrication schedule shall be submitted by the contractor along with the tender.

18) TECHNICAL DATA:

Technical data of all equipment shall be furnished as required.

19) TENDER CLARIFICATIONS:

The contractor shall note that if any clarifications regarding specifications, conditions of contract, schedule of quantities, or scope of works are required, he should contact Department, Directorate of Construction Services & Estate Management, Department of Atomic Energy, Mumbai: 94 on working days during office hours. No claim on account of any ambiguity in any respect will be entertained.

20) CONTRACTOR'S LIABILITY FOR LOSS, DAMAGES ETC:

During the execution of contract and until completion certificate issued, the contractor will be fully liable to compensate all concerned for any loss, damage

or destruction of “Works” structures, Plant and machinery, persons, property etc., including third party risk arising due to causes attributable to the contractor as may be decided by the Department’s Representative whose decision in this regards shall be final.

21) INFORMATION TO BE INCLUDED WITH THE TENDER:

The tender shall contain sufficient information to permit a detailed comparison and evaluation of the tenders, including provision of data called for in this tender. All supporting information, technical data, specification required under the various sections of the tender forms and for which there is insufficient space included there in shall be set forth for each part as a separate appendix marked to show clearly specific sections to which it is an appendix. In each case where appendixes are necessary, the forms “See Appendix No.” shall be shown under its specific part and further such appendixes shall be listed. Any tender not supported by the information requested in this tender document is liable to be rejected. Energy economy oriented equipment / design will only be considered.

22) DEVIATIONS FROM ORIGINAL TENDERS:

The contractor shall submit two (2) copies any suggested deviations from the tender documents in the bid itself for consideration by the Department. These deviations if accepted shall constitute part of the contract, if approved by the Department.

23) LIST OF CODES AND STANDARDS

- National Building Code of India – 2016
- Energy Conservation Building Code (ECBC) 2007
- ASHRAE (American Society of Heating Refrigerating & Air conditioning Engineers) Handbooks

  Refrigeration 2006, Fundamentals 2009, Systems & Equipment 2008, Applications 2007
- Duct construction standards as per SMACNA standards.
- Indoor Air Quality as per ASHRAE Standard 62.1 – 2007
- ASHRAE Standard 55-2004
- ASHRAE Standard 90.1-2007
- Air filters as per ASHRAE Standard 52.2
- National Fire Protection Association (NFPA) codes
- National Electric Code
- IS 277 Galvanized steel sheet (Plain & Corrugated) wire for fencing.
- IS 655 Metal air ducts.
- IS 659 Air conditioning (Safety Code)
- IS 660 Mechanical Refrigeration (Safety Code)

- IS 737 Wrought Aluminium and Aluminium alloy sheet & strip for general engineering purposes
- IS 780 Sluice valves for water works purposes.
- IS 822 Code of procedure for inspection of welds.
- IS 2379 Colour code for the identification of pipelines.
- IS 3103 Code of practice for Industrial Ventilation.
- IS 3696 Safety code for scaffolds & ladders
- IS 4736 Hot-dip zinc coatings on steel tubes.
- IS 4912 Safety requirements for wall openings, railings etc.
- IS 5216 Code for safety procedures and practices in electrical works
- IS 5916 Safety code for constructions involving hot bituminous material
- IS 5312 Swing - check type reflux Non return valves for water works
- IS 6392 Steel pipe flanges.
- IS 7896 Data for Outside design conditions for India cities.
- BS EN:779 Filters
- IS 10609 Refrigerants - Number designation.
- IS 3615 Glossary of terms used in refrigeration and air-conditioning.
- IS 4831 Recommendation on units and symbols for refrigeration.
- IS 5111 Code of practice and measurement procedures for testing refrigeration compressors.
- IS 7613 Method of testing panel type air filters for air-conditioning and ventilation purposes
- ASHARE: 33 Method of testing for rating forced circulation air cooling and air heating coils.
- IS:1391 Split air conditioners.
- IS: 10594 Thermostat expansion valves.
- IS: 11329 Finned type heat exchangers for room air – conditioners.
- IS: 11330 Oil separators.
- IS: 11338 Thermostats for use in refrigerators, water coolers, beverage coolers etc.
- IS: 4503 Shell and tube type heat exchangers.
- IS: 3724 Specification for cartridge type heating elements.
- ARI: 495 - 61 Standard for refrigerant liquid receivers.
- ASA-B: 31.5 Code for refrigerant piping.
- BS: 5720 Code of practice for mechanical ventilation and air-conditioning in building.

- ARI: 410 Standard for forced circulating air cooling and air heating coils.
- IS: 3589 Specification for ERW pipes for water & sewage.
- IS: 1234 M.S. tubes & tubular.
- IS: 554 Pipe threads.
- IS : 823 Code of practice of metal arc welding.
- IS : 1536 Flanges.
- IS: 814 (I & II) Electrodes for metal arc welding.
- IS : 1239 (I & II) Mild steel tubes, tubulars& other wrought steel pipe fittinq
- IS: 817 Code of practice for training & testing of metal arc welders.
- ASI : B 16.25 Butt welding joints.
- ASTM A 53 Pipe steel black & Galvanised welded & seamless.
- ASTM A 135 Electrical resistant welded steel pipings.
- IS : 702 Hot bitumen.
- IS : 8183 Thermal conductivity.
- IS : 3183 Mineral Wool.
- IS : 1663 Method for tensile testing of steel sheet & Strip of thickness 0.5mm to 3mm.
- IS : 2629 Recommended practice for hot-dip galvanizing of iron & steel.
- IS : 210 Grey Iron casting
- ASME/ANSIB 16.1 Cast iron piping flanges / flanged fittings.
- ASME/ANS I 16.5 Pipe flanges/flanged fitting.
- IS : 848 Methods of performance tests for fans.
- IS : 2997 Air circulator type fan and regulators electric.
- IS : 3588 Axial flow fans, electric.
- IS : 6272 Industrial cooling fans (man coolers).
- IS 4894 Specification for centrifugal fans
- IS : 1520 Specification for horizontal centrifugal pumps for clear, cold, fresh water.
- IS : 5120 Technical requirement for rota dynamic special purpose pumps.
- IS : 9137 Code for acceptance tests for centrifugal mixed flow and axial pumps – Class-C.
- BS: 599 Method of testing pumps.
- IS : 325 Three phase induction motors
- IS : 1231 Dimensions of three phase foot mounted motors.

- IS : 4691 Degree of protection provided by enclosure for rotating electrical machinery.
- IS : 3202 Code of practice for climate proofing of electrical equipment
- IS : 4728 Terminal marking and direction of rotating for rotating electrical machinery.
- IS : 4029 Guide for testing three phase induction motors.
- IS : 4729 Measurement & evaluation of vibration of rotating ,electrical machines.
- IS : 4889 Method of determination of efficiency of rotating machines.
- IS : 2253 Types of construction and mounting of induction moto.
- IS : 2223 Dimension flange mounted induction motors.
- IS : 2968 Dimension of slide rails for electric motors.
- IS : 4722 Rotating electrical machines.
- IS : 7816 Guide for testing IR of rotating machines.
- IS : 1554 PVC insulated electric cables (Heavy Duty).
- IS : 694 (I) PVC insulated cable with copper conductor.
- IS : 8130 Conductors for insulated electric cables.
- IS : 3975 Mild steel wires for armouring cables.
- IS : 5831 PVC insulted and sheathed electric cable.
- IS : 3961 Recommended current ratinq of cables.
- IS : 732 Code of practice for electrical wiring installation upto 650 V.
- IS : 2274 Code of practice for electrical wiring installation above 650 V
- IS : 3043 Code of practice for earthing.
- IS : 900 Code of practice for installation & maintenance of induction motors.
- IS : 5224 Code of practice for maintenance of NC induction motor starter upto 1000V.
- IS : 5561 Electric power connectors.
- IS : 3914 Code of practice for selection of A.C. induction motor starters. Voltage not exceeding 1000 Volts.

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CHAPTER 2
WATER COOLED / AIR COOLED CHILLERS

1.1 SCOPE

This section deals with Design, supply, installation, testing and commissioning of water cooled / air cooled, centrifugal/screw Chillers of capacity as per the Schedule of Quantity (SOQ) also known as Bill of Quantity (BOQ) and drawing complete with multiple compressors, energy efficient motors, water cooled / air cooled condenser, insulated evaporator, flow switch, vibration isolators, integral refrigerant piping and wiring, all accessories required for automatic and safety controls mounted in central console panel and all mounted on a common steel frame including first charge of refrigerant & compressor oil working on Refrigerant R134A or CFC and HCFC free refrigerant.

The scope of this consists of but is not necessarily limited to the following:

- Manufacture and supply of BMS compatible chillers with associated motors, soft starter and accessories.
- All associated items herein to be supplied delivered and installed.
- Assembly of chiller components including connection of coolers, condensers, motors, compressors, purge system for low pressure machine etc. into complete refrigeration machines.
- Provide manufacturer's factory representative's services, including coordination, and start-up and testing supervision.
- Testing (factory and field), start-up supervision, training and providing necessary documentation and tools for operation.
- Carry out performance test run at site.

1.2 COMPRESSORS (TYPE & CAPACITY)

The chiller shall be Water cooled / air cooled centrifugal/ screw compressors chillers and the actual refrigeration capacity of chilling machine shall be as indicated in drawings and Bill of Quantities.

1.2.1 SCREW COMPRESSOR (CONSTANT SPEED/VARIABLE SPEED)

The compressor motor unit shall be semi-hermetic / Hermetic direct drive, high rpm at 50 Hz, twin screw compressor suitable for use with refrigerant R134a/CFC and HCFC free refrigerant.

It shall be complete with suction and discharge shut-off valves, relief valve, oil filter, suction filter, muffler, dual manual reset type pressure state, oil safety switch, refrigerant suction and discharge pressure gauges, crank case heaters and relays, direct coupled motor, oil separator, oil cooler.

The compressor shall incorporate automatic capacity control feature for better modulation at partial and full loads (25 % to 100% capacity range). The unit shall be provided with slide valve unloading for partial load operations. The compressors shall have reducing capacity down to 25% of full load condition. Motor shall be suction gas-cooled, hermetically sealed/semi hermetic, two or multi poles, squirrel cage induction type. Further, compressors should be in unloaded condition during starting. The compressor should be supplied by the OEM of chiller manufacturer.

The screw compressor shall be fixed/ variable speed as per the system design and as per the schedule of quantities. In case of variable speed compressors, the chiller unit shall have factory mounted variable speed drive. The compressor shall unload from fully loaded to the minimum capacity by means of VFD (in case of VFD chillers).
There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shut down. The rotor(s) shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during start-up, running and during shut down. An oil sump heater shall be provided in the casing.

1.2.1.1 ELECTRIC MOTOR

Motor shall be energy efficient and suitable for 415±10% volts, 3phase, 50cycles AC supply.

Open type / Hermetic / semi hermetic motors as required shall be suction gas cooled, two pole, squirrel cage induction types. In case of open compressor type motors shall be screen protected drip proof squirrel cage induction type. Motor shall be designed and guaranteed for continuous operation. Insulation of motors shall be `F' class. Temperature rise of motor under rated service conditions shall not exceed 80 Deg C (by resistance method of measurement) over an ambient of 40 Deg C. the motor shall be provided with a combination of ball and roller bearing or as per OEM design. Factory assembled Terminal box of sturdy construction shall provide enough space for terminating, connecting and earthing of XLPE insulated aluminium /copper conductor cable as per the SOQ. All terminal boxes shall be located at the same side of the motor and have terminal and cable glands suitable for the specified cables. The total efficiency shall include losses of the auxiliaries such as independent excitation, motor-driven fans, lube-oil pumps etc.

All compressor motors in screw chillers shall be provided with VFD or without VFD as specified in the SOQ / BOQ or drawing.

1.2.1.2 STARTER

IP 42 for indoor type and IP-55 or IP 54(as per site conditions) for outdoor type enclosure with top power wiring access and three phase solid-state overload protection. The motor shall be suitable for operation on 415 + 10% volts, 3 phase, 50 HZ alternating current supply, unless otherwise specified.

The starter shall be factory mounted and completely pre-wired to the compressor motor and the control panel. It should also have an additional feature like circuit breakers and mechanical non-fused disconnects. Emergency stop push button shall be provided in the local control station. Starting current at rated voltage and frequency shall not exceed 2 times of full load current at rated voltage and frequency.

Motor Starters: Motor starters shall be zero electrical inrush current (Variable Frequency Drives) or reduced inrush type (Closed transition Star-Delta or Solid State) for minimum electrical inrush. Open transition Star-Delta and Across the Line type starters will not be acceptable.
Power factor correction capacitors as required to maintain a displacement power factor of

95% at all load conditions shall be provided.
Each starter shall be provided with the following protections: -

a) Thermal overload on all the three phases with adjustable settings,
b) Under voltage protection, and
c) Independent single phasing preventer. (current sensing type)

Adequate number of extra NO/ NC contacts for interlocks, indicating lamps etc. shall be provided the starter/ contactor.

1.2.1.3 MICROPROCESSOR BASED INTEGRAL CONTROL PANEL:

The chiller shall be controlled by a standalone microprocessor based control panel. Microprocessor shall be capable of supporting remote management

Each Unit shall be suitable to connect to the central controller.
The chiller control panel shall control of chiller operation and shall monitor chiller sensors, actuators, relays and switches.

The chiller control panel shall be equipped with: -

i) System operating information including:
a. Chilled water inlet and outlet temperature
b. Evaporator and condenser refrigerant temperature and pressure
c. Oil pressures
d. Percentage of power consumption & motor current
e. Compressor discharge temperature & pressure
f. Oil reservoir temperature
g. Flow switch status
h. Approach temperatures

ii) Chiller package status like start-up sequence status & shut down and operation status:-
a. Operating hours (Total hours)
b. Number of starts of compressor & Compressor ON & OFF status
c. Compressor unloading status
d. Time of last start and time of last stop
e. Fault history

iii) Digital programming of set points through the universal keypad including
a. Leaving chilled water temperature
b. Percent current limit
c. Pull-down demand limiting
d. Minimum six-weeks schedule for starting and stopping the chiller & chilled water pump
e. Remote reset temperature range

iv) Status messages indicating:
a. system ready to start
b. system running
c. system close down

d. system safety shutdown-manual restart

e. system cycling shutdown-auto restart

i) Safety shutdowns enunciated through the display and the status bar and consist of system status, system details, day, time, cause of shutdown and type of restart required. Safety shutdowns shall include:

a. evaporator – low pressure
b. evaporator – low temperature
c. Anti-freeze protection cut-out
d. condenser – high pressure
e. discharge – high temperature
f. oil – high / low temperature
g. oil – high / low pressure
h. control panel – power failure indicator
i. motor or starter – current imbalance
j. Electrical over load (current)

ii) Security access to prevent unauthorized change of set points, to allow local or remote control of the chiller. Access shall be through ID and password recognition, which is defined by three different levels of user competence: view,operator and service.

iii) The operating program stored in non-volatile memory (EPROM) to eliminate reprogramming the chiller due to AC power failure or battery discharge. Programmed set points shall be retained in lithium battery-backed RTC memoryfor a minimum of 5 years with power removed from the system.

iv) A fused connection through a transformer in the compressor motor starter to provide individual over current protected power for all controls.

v) An RS-232 / 485 port to output all system operating data, shutdown / cycling message and a record of the last 10 cycling or safety shutdowns to a field- supplied printer. Data logs to a printer at a set programmable interval. This datacan be pre-programmed to print.

vi) The capability to interface with any third party building automation systemto provide:

a. remote chiller start and stop
b. remote chiller leaving temperature adjust
c. remote current limit set point adjust
d. safety shutdown
e. cycling shutdown
f. run & shut down status

11. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system

1.2.1 Also necessary hardware cards and software shall be provided for integration ofthe chiller micro panel with the PLC based building automation system to ensure two way communications and the system should be achievable through remote BMS system.CENTRIFUGAL COMPRESSORS (CONSTANT SPEED AND VARIABLE SPEED)

The compressor shall be open/semi hermetic / hermetic single or dual centrifugal compressor (as per SOQ / BOQ) suitable for use with refrigerant R-134a/ **CFC and HCFC free refrigerant**.

The centrifugal compressor **shall be fixed/ variable speed.** The variable speed compressor shall have compressor/ chiller manufacturer ‘s factory matched variable speed drive.
The impeller is designed for operation at speed higher than the drive motor, necessary speed increasing gear shall be connected to the impeller shaft in a self-aligning and balanced way. The gears and pinion shall be pressure lubricated.
The compressor shall incorporate the necessary design features to take both axial and radial thrusts. The bearings shall be of self-aligning type.

The impeller shall be statically and dynamically balanced and over speed tested so as to ensure vibration free operation. The impeller shaft or drive end of the gear shaft, as the case may be, shall be connected with the motor through a flexible coupling in case of open design and rotor shaft in case of hermetic design.
The compressor shaft seal be as per manufacturer ‘s standard design. The seal must effectively prevent the leakage of refrigerant during shut down periods.

The compressor shall incorporate automatic capacity control feature for better modulation at partial and full loads (25 % to 100% capacity range**.** The pre rotation vanes located at the impeller inlet for controlling the capacity shall be aerofoil shaped and shall be made as per manufacturer ‘s standard. The vane position shall be controlled through hydraulic/ linkage system.
The positioning of the vane shall be through microprocessor-based controller with its sensing elements in the outgoing chilled water lines.

1.2.2.1 ELECTRIC MOTOR
Motor shall be energy efficient and suitable for 415±10% volts, 3phase, 50cycles AC supply.

Open type / Hermetic / semi hermetic motors as required or as recommended by Manufacturer shall be suction gas cooled, two pole, squirrel cage induction types. In case of open compressor type motors shall be screen protected drip proof squirrel cage induction type. Motor shall be designed and guaranteed for continuous

operation. Insulation of motors shall be `F' class. Temperature rise of motor under rated service conditions shall not exceed 80 Deg C (by resistance method of measurement) over an ambient of 40 Deg C. the motor shall be provided with a combination of ball and roller bearing or as per OEM design. Factory assembled Terminal box of sturdy construction shall provide enough space for terminating, connecting and earthing of XLPE insulated aluminium /copper conductor cable as per the SOQ. All terminal boxes shall be located at the same side of the motor and have terminal and cable glands suitable for the specified cables. The total efficiency shall include losses of the auxiliaries such as independent excitation, motor-driven fans, lube-oil pumps etc.

All compressor motors in Centrifugal chillers shall be provided with VFD or without VFD as specified in the SOQ / BIOQ or drawing

1.2.2.2 Motor starter

A. For constant speed compressor

Starter for motor shall be as per details given under **para 1.2.1.2**

B. For variable speed compressor

a. In Case of VSD starter, it will vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The adaptive capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.
b. To Limit Harmonic generation from VSD, Active Harmonic Filters as per IEEE 519 must be used at the source itself.
c. Drive will be PWM type utilizing IGBT's with a power factor of 0.95 or better at all loads and speeds.
d. Make of VSD shall be exactly same as per global catalogue / practice. The variable speed drive shall be with all power and control wiring between the drive and chiller factory installed, including power to the chiller oil pump.
e. Field power wiring shall be a single point connection and electrical lugs for incoming power wiring will be provided.

C. The following features will be provided:

a. Door interlocked circuit breaker capable of being padlocked.
b. UL listed ground fault protection.
c. Over voltage and under voltage protection.
d. 3-phase sensing motor over current protection.
e. Single phase protection.
f. Insensitive to phase rotation.
g. Over temperature protection.

Digital readout at the chiller unit control panel of output frequency, outputvoltage, 3-phase output current, input Kilowatts and Kilowatt-hours, self- diagnostic service parameters. Separate meters for this information will not be acceptable.

1.2.2.3 MICROPROCESSOR BASED INTEGRAL CONTROL PANEL: -

Microprocessor Based Integral Control Panel Starter shall be as per details given under **para 1.2.1.3** wherever it applied.

1.3 EVAPORATORS/CHILLERS

Evaporators/Chillers shall be of shell & tube Flooded Design type comprising of single or two independent circuit compressor as specified in the SOQ. The Chiller shall use R-134A / Environment. Friendly refrigerant only with fully charged. The Chiller shall be designed for total capacity as per SOQ at operating chilled water at temperature differential of 5 deg. C or 5.5 deg C. at 100% load as per AHRI conditions. However, the capacity of the chiller has to meet the tonnage specified at the respective LWT mentioned in the schedule of quantities and established by the vendor/OEM by submitting AHRI selection sheet clearly indicating the capacity as per schedule of quantities. The Fouling factor to be considered for chiller shall be 0.0001 FPS unit (Hr. sq. Ft. ^{0}C temperature difference / BTU) unless otherwise specified in the tender specifications.

The chiller shall be made of rolled carbon steel plate with fusion welded seams. Removable compact water boxes of cast iron or welded steel with stub-out water connections shall be provided to permit access for tube cleaning and replacement.

Water boxes shall be designed for 150 psig working pressure and hydraulically tested at 225 psig. The tubes shall be finned from outside having spiral ridges from inside, roller expanded into the tube sheets providing a leak-proof seal. The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness as per applicable standard code of practice (minimum of 0.71 mm) for plain tubes & minimum 0.63mm at the root of fins. Intermediate steel tube supports should be provided at intervals not exceeding 1200 mm.

Chillers shall be suitable for use with thermostatic / electronic expansion valves as refrigerant feeding device. Provision shall be made on the chiller for fixing manually reset-type antifreeze thermostat. Chiller shall be provided with eliminator to prevent liquid carry over to the compressor.

The chiller shall be provided with liquid level sight glass and a relief device (of the bursting type) to prevent excess pressure in the heat exchanger.

The chiller shall be provided with the following connections and accessories

- Refrigerant inlet and outlet pressure gauges.
- Grooved coupling at Water inlet and outlet connections.
- Drain and vent connections with stop valves.
- Pressure gauges on water inlet and outlet connections.

- Descaling valves.

Chiller shall be insulated with 19 mm thick nitrile rubber insulation. The insulation shall be set with compound recommended by the insulation manufacturer and shall be applied sealing the joints. The insulation shall be applied in such a manner that water boxes and covers shall be removable without damaging it.

The chiller's performance certification shall be done in accordance with AHRI Standard 550/590. The chillers that are listed in the AHRI certification are preferred. Tenderer shall include Performance Rating Chart (computer selection printout) duly certified by AHRI for all guaranteed outputs. The initial charge of refrigerant and oil will be factory charged in the chiller.

1.4 CONDENSERS

The condenser shall be of shell & tube construction and shells will be of rolled carbon steel plate with fusion welded seams. Removable compact water boxes of cast iron or welded steel with stub-out water connections shall be provided to permit access for tube cleaning and replacement. Water boxes shall be designed for 150 psig working pressure and hydraulically tested at 225 psig. The tubes shall be finned from outside having spiral ridges from inside, roller expanded into the tube sheets providing a leak-proof seal. The tube material will be copper, intermediate steel tube supports should be provided at intervals not exceeding 1200 mm. Grooved coupling at Water inlet and outlet connections.

1.5 AMBIENT CONDITIONS:

The system shall be capable of operating within a wide range of maximum ambient temperature of 45 Deg. C. DB and should be capable to achieve the chilled water as specified in SOQ.

1.6 CHILLER FRAME:

The Chiller shall be included with anti-corrosive adequate structural base frame in order to ensure resistance to external environmental corrosion, the structure and panels of the casing are produced entirely in galvanized steel. The paint conforms to ASTM B117 standard regarding resistance to saline humidity; therefore, the units can be installed in even the most testing of atmospheric conditions. All external fastenings are in stainless steel. The closing mechanism on the casing gives IP54 protection.

1.7 ISOLATION MOUNTING:

The chiller unit shall have vibration isolation mounts between floor and structural supports for field mounting. The chilling machine shall be installed over a platform and shall be adequately isolated as per manufacturers' recommendations against transmission of vibrations to the building structure.

1.8 TESTING:

The chiller shall be factory tested as well as site tested for establishing the capacity and power consumption. Refrigeration capacity shall be computed from measurement of water flow and entering & leaving water temperatures on chiller side. Flow measurement shall be through flow meters. Computed results shall tally with the specified capacities & power consumption figures furnished with the tender offer. Performance test shall be carried out as per procedure laid down by AHRI / EUROVENT and as per department specified parameter, at minimum two points. The chiller should not be despatched from the factory unless these have been witnessed and accepted by the Department on the performance. Also the performance testing of Chiller shall be carried out at site in addition to 72 hours of endurance testing as per relevant standards.

Test shall be carried out on:

i) The compressor and drive motor side for power consumption.
ii) Chiller side.

All meters, gauges thermometers, Watt meters shall be provided by contractor with duly calibrated. All necessary pipe pieces required for insertion of orifice plate assembly shall be provided by contractor during piping installation.

1.9 INTERFACE WITH HVAC BUILDING AUTOMATION SYSTEM

All necessary hardware / software to integrate the chiller panel to BAS system shall be provided free of cost by chiller manufacturer / supplier. For the integration of Microprocessor Panel of the chilling machine with the Building Automation System, an Interface Control Document shall be developed by BAS Contractor. It shall be responsibility of Chiller supplier to provide following to BAS Contractor for preparing the interface.

- Hardware Protocol of Chiller Microprocessor panel.
- Software Protocol of Chiller Microprocessor panel.
- Communication structure relating to collection of message / event information.
- Description of the formatted packets / blocks of data which construct controller commands / responses.
- Written permission to BAS contractor to develop the interface without any financial implication.

1.10 CODES & STANDARDS

The design, materials, construction, inspection, testing and performance of screw liquid chilling package shall comply with all currently applicable statues, regulations, codes and standards in the locality where the equipment is to be installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility. In particular, the screw liquid chilling package shall conform to the latest edition of following standards:

ASHRAE 15 Safety Code for Mechanical Refrigeration
ASHRAE 23 Method of testing for rating positive displacement refrigerant compressors and condensing units.
ASHRAE 30 Methods of testing liquid chilling packages.

ASME SEC VIII DIV 1 Boilers and pressure vessel code
ANSI B 31.5 Code for Refrigeration piping.
AHRI 550 / 590 Performance rating of water chilling using the Vapour compression cycle.
AHRI 575 Standard for method of measuring machinery sound within an equipment space.
TEMA Standards of the Tubular exchanger manufacturers association

CHAPTER 3
ELECTRIC HOT WATER GENERATORS

2.1 SCOPE:
The scope of this clause comprises the supply, installation, testing & commissioning of electric fired Hot Water Generator system, as mentioned in the detailed schedule of quantities and as per the relevant Indian Standards.

2.2 CONSTRUCTION:
The hot water generator shall be vertical/horizontal shell type. The shell shall be constructed out of 6 mm and Dish end shall be constructed out of 8 mm thick MS sheet with electric fusion welded seams.

The shell shall be duly insulated and shall be mounted in a cabinet of suitable angle iron frame made from 16 SWG mild steel sheet complete with hinges, locks etc. to make a sturdy compact assembly. The cabinet shall be provided with sufficient ventilation for heater terminals of the boiler. The angle iron frame shall be provided with lifting lugs and pedestals.

The heaters/electric resistance type heating elements shall be provided in such a way as to provide balanced distribution of the load. The heaters shall be capsulated in seamless copper tubes, flange mounted with stainless steel studs. The heaters shall be easily removable without needing the opening of terminal plates. The heaters shall be suitable for 230 V ± 10%, 50 ± 3% Hz single phase AC or 415 V ± 10%, 50 ± 3% Hz three phase AC supply as per SOQ and will be in direct contact with water contained in the shell.

2.3 CONTROLS & ACCESSORIES:
The hot water generator will be provided with and not limited to following controls & accessories.

a) 150 mm dia. dial type, temperature gauge of SS construction (Range 0 – 100° C) at inlet & outlet as specified in the schedule of quantities.
b) 150 mm dia. dial type, bourdon tube type pressure gauge of SS construction having appropriate pressure range at inlet & outlet as specified in the schedule of quantities.
c) Flow switch, float switch, automatic alarm for low water level and high temperature with independent indication lights.
d) Pressure relief valves (minimum 2 nos. for different setting).
e) Inlet & outlet pipes with flanges.
f) Drain points with valves.
g) Descaling valves.
h) Automatic air-vent.
i) Thermostat for individual heater banks or step controller.
j) Safety thermostat.
k) LED/ Jewel Lamp Indicators.
l) Localized controller for turning off the generator if hot water generator fails to turn off automatically if water temperature rises beyond 90° C.

2.4 PRESSURE TESTING:

The hot water generator shall be tested in the factory at 250 PSI.

2.5 INSULATION:

The hot water generator shall be insulated with 50 mm thick fiber glass of minimum density 32 kg/m3 and cladded with 0.60 mm aluminum sheet on MS frame welded on generator body.

2.6 PAINTING:

The external surface of the shell shall be de-rusted, cleaned and applied with three coats of primer and finally have powder coating of approved shade.

2.7 SPECIFICATION SUMMARY:

Vertical Type Electrical Hot Water Generators. Entire Hot Water Generator shall be factory assembled and tested. Only Inlet and Outlet Water Piping Connection and 415V / 4 Wire / 3 Phase / 50 Hz AC Power Supply connection shall be provided at site.

M.S.BODY CONSTRUCTION	6 mm thick shell with 8 mm thick Dish Ends. Top will be removable 8 mm thick MS Flat Plate with required Nut Bolts. The hot water generator is mounted on minimum 80 mm high M.S Channel.
INLET – OUTLET	ERW Heavy Class Pipes with Flanged End Connections of required size.
HEATING ELEMENT	Electric Resistance Immersion Type, Copper Tube duly Chrome Plated, flanged type. The heating elements shall be in 3 Banks of equal capacity, suitable for 230V / 50Hz AC Power supply, or 415 V 3 phase power supply as per SOQ.
TEST PRESSURE	250 PSIG as per ASME Pressure Vessel Code.
INTERNAL WIRING BASED CONTROL PANEL	Internally factory Wired complete with Microprocessor.
CONTROLS	High Temperature Microprocessor Step Controller, Pressure Gauges with Ball Valve, Pressure Relief Valve, Low Level Cut-Out with Sight Glass, Hooter, Fault indication Lights and Auto Air Vent.
INSULATION	50 MM thick Resin Bonded Fiberglass, Density of 32Kg/m3 duly cladded with 0.6 mm Aluminum Sheet on MS frame welded to Generator Body.

CHAPTER 4
COOLING TOWER

3.1 SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of cooling towers in accordance with requirements of Drawings and of the Bill of Quantities.

3.2 TYPE & CAPACITY

The cooling tower shall be of Mechanical draft type. Fan on Mechanical draft towers may be on the inlet air side or exit air side. In case of former it is called forced draft type and in case of later it is called Induced draft type. On the basis of direction of air flow and water flow, Mechanical draft cooling tower can be counter flow or cross flow type as per the manufacturer design. Cooling Towers type and capacity shall be in accordance with requirement of Drawings and Bill of Quantities. Cooling Tower shall be CTI certified

3.3 COMPONENTS OF COOLING TOWER

The basic components of cooling tower are: Frame and casing, single cell, fill, cold water basin, drift eliminators, air inlet, louvers, nozzles and fans in accordance with SOQ and Drawing.

3.4 FRAME AND CASING

Cooling towers shall have structural frames that support the exterior enclosures (casings), motors, fans, and other components. The cooling tower shall have single-cell construction. This shall be made out of FRP construction with smooth surface on both sides for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind velocities and vibration. The casing may be installed in the reinforced cement concrete basin if so identified in drawings, or in Bill of Quantities. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminium or PVC louvers integrated with fill and backed up by galvanized bird screen shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning. The fan guard shall be designed to prevent contact between fan and human finger.

3.5 FILL

Fillings shall be made of corrosion proof and rigid PVC film in honey comb design and arranged in square / rectangular form to facilitate heat transfer by maximising water and air contact. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back

water spots and prevent fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

3.6 COLD WATER BASIN:

The cold water basin shall be located at or near the bottom of the tower, to receive the cooled water that flows down through the tower and fill. The basin usually has a sump or low point for the cold water discharge connection. Cold water basin shall be a made of FRP.

Basin fittings shall include the following :

- Bottom outlet & Screened suction assembly.
- Drain connected to the side / underside of basin.
- Quick fill & Overflow connected to the side of basin.
- Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
- Ball type automatic make up water valve.
- Float Valve
- Equalizing connection and balancing valve for multiple CTs.

3.7 DRIFT ELIMINATORS

Drift eliminators capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere. Drift eliminators shall be efficient enough to effectively limit drift loss to no more than 0.005% of the designed flow rate.

3.8 AIR INLET

This is the point of entry for the air entering a tower. The inlet may take up an entire side of a tower for cross flow design or be located low on the side or the bottom for counter flow designs.

3.9 LOUVERS

The purpose of louvers is to equalize air flow into the fill and retain the water within the tower. The cross-flow towers have inlet louvers and counter flow tower designs do not require louvers.

3.10 NOZZLES

These provide the water sprays to wet the fill. Uniform water distribution at the top of the fill is essential to achieve proper wetting of the entire fill surface. Nozzles can either be fixed in place and have either round or square spray patterns or can be part of a rotating assembly as found in some circular cross-section towers.

3.11 FAN & MOTOR

The fan shall be axial-flow type, belt driven, multi aero foil blades with variable pitch. The fan blades shall be made of aluminium alloy and housed within a fan cylinder, design for smooth unobstructed air entry. The fan shall be factory balanced both statically and dynamically. A fan having non-automatic adjustable pitch blades permits the same fan to be used over a wide range of kW with the fan adjusted to deliver the desired air flow at the lowest power consumption. Automatic variable pitch blades can vary air flow in response to changing load conditions. Direct driven fan speed shall not exceed 700 RPM.

The fan motor shall be totally enclosed fan-cooled, weather proof type. It shall be connected through a set of easily adjustable and low maintenance.

Fan shall be driven by 415±10% volts, 3 phase, 50 cycles, AC supply, energy efficient motor, totally enclosed air over (TEAO), fan-cooled, weather-proof construction (IP55), Class F, designed and selected to operate in humid air stream. Fan shall be protected by a fan guard and bird screen of galvanized steel construction to prevent birds from nesting during idling period & shall be easily accessible for inspection and maintenance. G.S.S canopy shall be provided over the fan motor for protection against rain water. Motor terminal box shall be made water tight. The motor and cooling tower shall be designed suitable for operating at 115% of design capacity. The cooling tower fan motor shall be suitable for operating with Variable Frequency Drive as specified in the BOQ.

3.12 DESIGN

i) Rating:
The cooling tower shall be rated for the heat rejection capacity specified in the tender specifications. All cooling towers shall be certified by CTI (Cooling Tower Institute).

ii) Range:
The Cooling tower shall be designed to cool the requisite quantity of water through 4.2-degree C or as specified in the tender specifications, against the prevailing wet bulb temperature.

iii) Wet Bulb approach:
The cooling tower shall be selected for a wet bulb approach of not more than 2.77-degree C.

iv) Outlet temperature:
The cold water temperature from the cooling tower shall match the entering temperature for which the condenser selection is made.

v) Flow rate:
The water flow rate through the cooling tower shall match that through the condenser.

vi) Multi cell design:
The induced draft cooling tower shall be of one or more cells.

3.13 HANDRAIL & LADDER

Hot Dipped Galvanized made Ladder & Handrail should to access to the top of the cooling tower should also be part of scope.

3.14 CONTROL SYSTEMS

It should be possible to hook up to BMS. All necessary hardware & software should be part of the scope

3.15 VIBRATION ISOLATORS

Vibration Isolators of spring open type designed to minimize any vibration from transmitting to other structures to be included in the scope of supply.

3.16 LOW NOISE TYPE

Cooling tower supplied should be of low noise type & noise level at 5 mtr distance from the tower should not be more than 76 dBA.

3.17 DISTRIBUTION SYSTEM

Hot water distribution system shall comprise of header and branch arms system with flow balancing system or open pan gravity flow system. No overflow or splash of water shall be allowed at design flow rates.

3.18 PERFORMANCE DATA

Complete performance ratings and power consumption at varying loads and outdoor wet bulb temperatures, shall be submitted and verified at the time of testing and commissioning of the installation.

3.19 TESTING

Capacity of the cooling tower shall be computed from the measurements of water flow, incoming/outgoing water temperatures and ambient air wet bulb temperature using accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption for cooling towers shall be computed from measurements of incoming voltage and input current.

CHAPTER 5
CENTRIFUGAL PUMPS

1) SCOPE

The scope of this clause comprises the supply, installation, testing (at manufacturer's works before dispatch to site and once again at site after installation before commissioning) and commissioning of centrifugal pumps, conforming to this specification and in accordance with requirements of the schedule of quantities.

2) TYPE & CAPACITY

CHILLED WATER PUMPS:

Centrifugal pumps of orientation, capacity and head as per Schedule, for air conditioning applications. The pump and motor shall be of weatherproof construction. The Pump motors shall be VFD compatible wherever indicated in the BOQ. By measuring pressure differential between chilled/hot water supply and return headers, the speed of chilled water booster pumps shall be automatically varied.

3) CASING

Pump Casing - Cast Iron MOC and working pressure up to 12 bar at 65°C (PN16 flange rating). Suction and discharge connections shall be flanged and shall be drilled and tapped for seal flush and gauge connections. The casing along with the motor shall be on a common base frame and appropriate anti-vibration arrangements shall be provided.

4) IMPELLER

Impeller shall be G.M/Bronze, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. The impeller shall be secured to the shaft by feather and nut.

5) WEARING RINGS

Wear rings shall be provided for pump's impeller as well as in the casing to maintain close running clearance and to minimise pressure leakage between suction and discharge chambers of the casing. The casing wearing rings shall protect the casing against wear and shall be locked in pump casing to prevent rotation.

6) SHAFT

Shaft shall be high strength stainless steel. Pumps shall be fitted with outside balanced mechanical seals (factory fitted). The shaft shall be of with optimum diameter to provide maximum strength with minimum shaft deflection.

7) PUMP MOTOR

Motor shall be energy efficient, totally enclosed, fan-cooled with Class-F electrical insulation. Motor shall be specially designed for quiet operation and its speed shall not be exceeding 1500 RPM. The motor rating shall be such as to ensure non overloading of the motor throughout its capacity range. Motor shall be suitable for 415±10% volts, 3 phase, 50 Hz±3%, AC power supply. The motor type shall be of high efficiency (IE-3). The motor shall be provided with the type of starter as specified in the BOQ.

8) COUPLING

Rigid spacer type coupling for vertical pump-sets / Flexible coupling for horizontal pump-sets and of make as recommended by the pump manufacturer shall be provided along with coupling guard.

9) SEAL

The mechanical type seal should be a balanced type with multiple springs, made primarily of stainless steel. The seal face should be made of silicon carbide. The secondary seal, shall be made of Viton. The seal should come with a stainless steel gland plate and trim to hold the seal assembly together and with necessary gland drain connections if required. The seal should also come with a factory-installed flush liquid line to keep it cool and clean and a manual vent used to remove air from the flush line shall also be provided. The pump should have a lower seal chamber throttle bushing to control the flow of the flush liquid back to the pump. If required, the seal should come with fittings for the flush line. The flush line should also have a 50-micron cartridge filter and a sight flow indicator, to filter the flush liquid and monitor its flow, respectively. After the system is flushed, the filter should be easy to change. For pumps with differential pressures exceeding 200 kPa, a cyclone type separator shall be provided in the flush line instead of the cartridge filter.

10) ALIGNMENT

The pump and motor shall be aligned by the pump manufacturer. The pump manufacturer shall provide certification to the effect that the pump and motor coupling has been carried out by them and checked by them and that no need for realignment will be required after installation.

11) PAINTING

All HVAC pumps, motors and bases shall be supplied with medium blue paint finish. Shop coat of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the adjoining areas.

12) TESTING AT MANUFACTURER'S WORKS

Before dispatching the pump sets to the site the contractor shall carry out tests as per the plan approved by the Engineer in Charge and to the satisfaction of the Engineer in Charge. These tests shall be performed at the Pump manufacturer's works. The tests shall ensure that the specified flow rate and head are achieved, by means of Direct Reading Flow meter. The pump sets shall be dispatched to the site only after getting prior approval from the Engineer in Charge.

The following tests shall be conducted at the rated RPM of the pump in the presence of Engineer in Charge for performance as per relevant IS Standards.

- Discharge Vs Head
- Discharge Vs Efficiency
- Discharge Vs BHP
- Hydraulic tests for casing at 1.5 times of the design pressure

Performance tests shall be conducted at the following operating points.

- Shut Off
- Rated duty point
- 120% rated capacity.

The contractor shall submit detailed performance curves for the pumps supplied along with the tender.

The pump head given in the SOQ / Drawing is minimum required for the system. Actual head shall be calculated and confirmed by the vendor at the time of bidding. The pump head calculation based on the approved shop drawings shall be submitted by the vendor and upgrade the pump & motor to the requirement, without any extra cost to the Engineer in Charge.

13) INSTALLATION

The pump shall be installed on RCC Foundation of dimensions as recommended by the pump manufacturer. The grade of concrete and design as well as quantity of rebar used in making the pump foundation, shall be as per department's instructions. G.I J-Bolts along with 2 G.I nuts per bolt shall be used for anchoring the pump-set to its foundation. Installation shall be done as per the Manufacturer's drawing. Pump RCC foundation shall be with M.S Angle frame along the edges of the foundation, made of 50x50x5 mm M.S Angles. The pump shall be capable of getting installed with pipe support and without flexible connectors on the suction and delivery side.

14) REGULATORY REQUIREMENTS

- Conform to Health/Life Safety Code
- Conform to International Mechanical Code
- Conform to BOCA National Building Code
- Conform to State of Illinois Plumbing Code
- Conform to National Electric Code NFPA 70
- Conform to applicable ANSI/HI standards
- Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

15) DELIVERY, STORAGE & HANDLING

- Deliver materials to the site in such a manner as to protect the equipment & materials from shipping and handling damage. Provide equipment & materials, on factory provided shipping skids and lifting lugs, if required for handling. Equipment & materials that could be damaged by the elements should be packaged in such a manner that they could withstand short-term exposure to the elements during transportation.
- Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

16) PERFORMANCE TESTS AT SITE

The contractor shall after installation carry out commissioning tests as per the plan approved by the Engineer in Charge and to the satisfaction of the Engineer in Charge and ensure that the specified flow rate and head are achieved, by means of Direct Reading Flow meter.

The following tests shall be conducted at the rated RPM of the pump in the presence of Engineer in Charge for performance as per relevant IS Standards.

- Discharge Vs Head
- Discharge Vs Efficiency
- Discharge Vs BHP
- Hydraulic tests for casing at 1.5 times of the design pressure

Performance test shall be conducted at the following operating points.

- Shut Off
- Rated duty point
- 120% rated capacity.

17) COMPONENTS OF VARIABLE SPEED PUMPING SYSTEM WHEREVER INDICATED

Pump Logic Controller should be fully compatible to hook up to BMS/Chiller Plant manager.

- The technologic pump logic controller shall be factory assembled with UL listed components.
- The Equipment should be able to hook up to BMS via software integration either in BacNet / RTU Modbus Protocol. Necessary hardware & software for integration should be part of scope.
- The controller shall be specifically designed for variable speed pumping applications.
- The controller shall function to safeguard the equipment and materials against damaging hydraulic conditions including:
  - Pump flow surges
  - Hunting
  - End of curve
  - System over pressure
- The pump logic controller shall be capable of receiving up to two discrete analogue inputs from zone sensor / transmitter. It shall then select the analogue signal that has deviated the greatest amount from its set point. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling up to three pumps in parallel.
- The pump logic controller shall be capable of accepting an additional analogue input from a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.
- The pump logic controller shall be self-prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:
  - Multi-fault memory and recall last 10 faults and related operational data.
  - Red fault light, yellow warning light and Green power on light.
  - Soft-touch membrane keypad switches.
- The display shall have four lines, with 20 characters on three lines and eight large characters on one line. Actual pump information shall be displayed indicating pump status.
- Controller shall be capable of performing the following pressure booster functions:

- Low suction pressure cut out to protect the pumps against operating with insufficient suction pressure.
- High system pressure cut out to protect the piping system against high-pressure conditions.

- The following communication features shall be provided to BMS:
  - Remote system start / stop non-powered digital input.
  - Failure of any system component. Output closes to indicate alarm condition.
  - Four 4-20 mA dc signals with output of
    i) Frequency
    ii) Process variable
    iii) Output current
    iv) Output Power
- The following communication features shall be provided to the Building Management system via an RS-485 port suitable to hookup either in BacNet / RTU Modbus protocol. Necessary hardware / software required for integration should be part of scope.
  - Individual Analog Input.
  - Individual Zone Set points.
  - Individual Pump / VFD on/off status
  - System percent speed
  - System start/stop command
  - System operation mode
  - Individual kW signals
  - System flow, when optional flow sensor is provided.

- The pump logic controller shall be of a high end type i.e. all the parameters available on the logic control panel should be able to monitor / controlled from the remote location and should be housed in a NEMA 1 Enclosure.

18) DIFFERENTIAL PRESSURE SENSOR / TRANSMITTERS

Provide field mounted differential pressure sensors/transmitters at the top most & most distant AHU. Unit shall transmit an isolated 4-20 mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have a corrosion resistant steel body with 1/8" NPT process connection. It shall have a NEMA 1 electrical enclosure capable of withstanding 450 PSI static pressure. Accuracy shall be within 0.5% of full span.

19) SEQUENCE OF OPERATION FOR HVAC PUMPS (WHEREVER AUTOMATION IS USED)

- The system shall consist of pump logic controller, VFDs, with manual and automatic alternation and pump staging.
- The pumping system shall start upon the closure of customer's contact when pump logic controller mode of operation selector switch is in the REMOTE position.
- When the pump logic controller selector switch is in the LOCAL position and start command on controller is given via operator interface, the pumping system shall operate automatically.
- Sensor / transmitter shall send a 4-20 mA signal to the pump logic controller, indicative of process variable condition.

- The pump logic controller shall compare each signal to the independent engineer / user determined set points.
- When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level.
- The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the latest satisfied zone.
- As the worst-case zone deviates from set point, the pump logic controller shall send the appropriate analogue signal to the VFD to speed up or slow down the pump/motor.
- In the event of a VFD fault, the pump logic controller automatically initiates a timed sequence of events to start the redundant pump/VFD set in the variable speed mode. The redundant variable speed system shall be started through the pump logic controller.
- Upon VFD faults, the pump controller shall display an alarm condition through a plain English message.
- VFD fault indication shall be continuously displayed on the operator interface of the pump until the fault has been corrected and the controller has been manually reset.
- In the event of the failure of a sensor/transmitter, its process variable signal shall be removed from the scan/compare program. Alternative sensor/transmitters, if available, shall remain in the scan/compare program for control.
- Upon sensor / transmitter failure a plain English warning message shall be displayed on the operator interface of the pump logic controller.
- In the event of failure to receive process variable signals, a user selectable number of VFDs shall maintain a user adjustable speed; reset shall be automatic upon correction of the failure.

CHAPTER 6
AIR HANDLING UNITS

1) SCOPE

The scope of this clause comprises of supply, erection, testing and commissioning of Sectionalized Double skin, air handling unit conforming of these specifications and in accordance with the requirement of drawing and the Schedule of Quantities.

2) TYPE & CAPACITY

The air handling units' type, configuration, CFM capacity, Cooling/Heating capacity, Fan static pressure, etc. shall be as shown in the drawings and given in the Schedule of Quantity.

3) UNIT COMPOSITION

The AHU shall be of the cabinet type double skin and of configuration as mentioned in schedule (also known as Schedule of Quantities (SOQ) / Bill of Quantities (BOQ)) and shall be of metal construction using best quality galvanized steel sheet treated for rust prevention. They shall be constructed in sections such as fan section, cooling coil section, heating coil section, damper section, filter section etc. suitable for floor/ceiling installation as mentioned in BOQ. The unit shall be fitted with unit mounted volume control damper. Refrigerant/Water supply and return headers shall be tapped and connected to the respective coils. VFD controls shall be used in AHUs wherever indicated in the BOQ, in order to control the quantity of supply air. The pressure drop across the filters shall be monitored through the HVAC - Building Management System (BMS), wherever applicable for periodical maintenance / replacement of filters.

4) CASING

The casing for air handling unit shall be of double wall/panel construction filled with minimum 43±2 mm thick polyurethane foam or equivalent fire retardant insulation (CFC and HCFC free) sandwiched between the panels. The density of PUF insulation material shall not be less than 48 kg/m3 and the thermal conductivity shall not exceed 0.02 W/m°K. The inner walls of AHU shall be of 0.8 mm plain galvanized sheet steel with coating of 180GSM or as indicated in the BOQ. The outer walls of AHU shall be of 0.8 mm pre-coated galvanized sheet steel with coating of 180GSM or as indicated in the BOQ. Section frames shall be of hollow anodized extruded Aluminium, internally insulated and mechanically joined. Units shall be with necessary air tight access doors with adjustable locking device for each section. Sections shall be bolted together with special cast Aluminium fittings at the joints with rubber gaskets for air tight operation. The AHU base frame shall be heavy duty GI section. AHUs shall be sized such that the dimensional clearances provided between various sections inside them are sufficient for carrying out all the necessary maintenance/replacement activities and also there is sufficient space around the AHU cabinet for running the chilled water pipes and hot water pipes.

5) BLOWER SECTION

The blower shall be statically & dynamically balanced, direct driven plug type centrifugal blower (single/multiple as per CFM requirement) or belt driven centrifugal fan as per relevant AMCA/ISO standards complete with aerofoil type impeller blades and of no overloading characteristics. Computerized AHU selection, fan selection

and noise data shall be furnished along with the specific frequency for each AHU capacity.

The blower and its motor shall be assembled on a common G.I base frame, which shall be mounted on the floor of the AHU casing with spring vibration isolators. The blower outlet shall be connected to the casing with fire retardant fabric acting as a flexible connection to avoid any vibration from the unit on to the ducts. The blower shall be selected for a noise level less than 65 dBA at 1.5m distance.

Blower casing shall be made of galvanized steel sheet. Blower wheels shall be made of galvanized steel of thickness not less than 2 mm. Its shaft shall be carbon steel and it's operating speed shall be at or less than 75% of first critical speed and it shall be supported on grease lubricated Plummer block type bearing housings. Its wheels shall be individually tested dynamically & statically balanced. Blowers will be of spark-less construction. Electrical inter lock shall be provided to ensure absolute safe operation. All screws, nuts & bolts shall be galvanized as per IS: 2629.

The motors shall suitably have selected to meet the requirements of CFM and Static Pressure and they shall be of IE3 type with IP 55 rating, they shall be totally enclosed, fan cooled and have class 'F' electrical insulation.

Isolation shall be provided from the unit casing by combination spring and rubber anti vibration mounts and flame retardant, waterproof neoprene impregnated flexible connection on the fan section & discharge as applicable.

The static pressure given in the AHU schedule is minimum required for the system. Actual static pressure shall be calculated and confirmed by the vendor at the time of the bidding. The static pressure calculation based on the approved shop drawing shall be submitted by the vendor and upgrade the fan & motor to the requirement, without any extra cost to the Engineer in Charge.

6) MOTOR & DRIVE

The motor shall be squirrel cage induction motor as per IS: 325 and with class "F" insulation, suitable for 415 V ±10%, 50 Hz ±3%, 3-phase, IE-3, totally enclosed fan cooled with IP-55 protection. It shall be suitable for variable speed operation by variable frequency drive, wherever applicable as indicated in the schedule. Backup Star Delta/ DOL starter shall also be provided for the motor. The motor shall be capable of handling the required starting torque of the AHU. Speed of motor shall be compatible with the speed of the blower. Motor shall have dust tight construction with suitable means of breathing and of drainage to prevent accumulation of water from condensation. Drain holes shall exclude bodies greater than 6mm diameter. All components shall be of adequate mechanical strength and robustness and shall be constructed of metal unless otherwise approved. Motor shall be dynamically balanced.

The enclosure shall be designed to provide an effective sealing between the primary and secondary air circuits. Motor winding shall be vacuum impregnated with heat and moisture resistant varnish, glass fibre insulated. Two independent earthing points shall be provided in accordance with IS:3043 on opposite sides of the motor for bolted connection. The cable boxes and termination shall be designed to enable easy

disconnection and replacement of cables. Blower-Motor shall be part of scope with AHU manufacturer & should not be supplied separately by HVAC Contractor.

7) COIL SECTIONS & MOISTURE ELIMINATOR

The coil sections of the AHU shall be of the cartridge type, removable from the side of the casing and supported over the entire length of the coil. The Coil sections shall have 12.5 mm to 15 mm dia, 0.41mm wall thickness copper tubes with 0.15mm thick sine wave Aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. The coil header shall be copper and the coil fins shall be supplied with Anticorrosive hydrophobic coating. Face and surface area shall be such as to ensure rated capacity from each unit and such that air velocity across each coils shall not exceed 500 ft/sec. Drift eliminator (4 pass W type) shall be provided downstream of the cooling coil to arrest entrained free moisture from the air stream. Appropriate panel of the coil sections shall incorporate factory made openings for coil inlet & outlet connections. The cooling and heating coils shall be mounted over an adequately sized common condensate drain pan. Particular care shall be taken to ensure that condensate is drained totally without leaving any stagnant pools anywhere in the unit. Each coil shall be factory tested under water. Tube shall be hydraulically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 11 to 13 fins per inch. The coils shall be mounted on castors to facilitate removal for cleaning. Flanges of resilient isolation material shall be provided both at the inlet and outlet connections of all coils with necessary bushes of similar material to minimize transmission of vibration to connected piping. Coils shall have automatic air vents, the vent outlets being piped to the drain pan with a copper pipe. Coil performance shall be rated in accordance with ARI Standard 410. Each coil shall be leak tested at 17 bars.

8) FILTER SECTION

Each unit shall be provided with factory assembled filter sections containing filter having anodised aluminium frame. Filter bank shall be easily accessible and designed for easy withdrawal and renewal of filter cells. Filter framework shall be fully sealed and constructed from aluminium alloy. The filter type shall be as specified in the Schedule of quantities. The filtration efficiency shall be as per ASHRAE 52.2 standards. Necessary access door shall be provided for accessing the filter sections.

9) DRAIN PAN & DRAIN PIPE

Extended drain pans (common for cooling coil, heating coil and extended up to the drift eliminator) for the AHUs shall be fully insulated with minimum 19mm thick nitrile rubber insulation over a panel of stainless steel. Drain pan connection shall be provided on both right and left hand sides. Condensate drain piping shall be insulated with 9 mm thick Nitrile rubber insulation. External drain piping shall be connected to both sides with suitable air seal trap.

10) SAFETY FEAUTRES

Each Air Handling unit shall have safety features as described below, but not limited to those listed below:

- The fan access door shall be equipped with micro-switch inter locked with fan motor to enable switching off the fan motor automatically in the event of door opening. The access door shall be further having wire mesh screen as an added safety feature bolted on to the unit frame.
- Fan and motor base shall be properly earthed from the factory.
- All screws used for panel fixing, projecting inside the unit shall be covered with PVC caps to avoid human injury.
- Air handling units shall be selected for the lowest operating noise level of the equipment. Fan performance rating and power consumption data, with operating points clearly indicating shall be submitted and verified at the time of testing & commissioning of the installation.
- Fans shall have AMCA certification. Fan Section including wheels and housing shall be fabricated from heavy gauge steel. Fan and motor shall be internally housed and mounted on a common steel base of channel section, epoxy coated with vibration isolation mountings for absolute silent and vibration free operation.
- Blower shaft shall be grounded C-4.0 carbon steel and supported in self-aligning plummer block mounted, grease lubricated bearings. Particular attention shall be paid to ensure reasonably low and acceptable noise level.

11) ACCESSORIES

All the accessories shown in the drawings as indicated shall be included. Each air-handling unit shall be provided with auto air vent as indicated in the schematics & drawings.

The following accessories shall also be provided;

- Inspection Window
- Bulkhead lightning.

The AHU shall be provided with suitable space provision for the field equipment of BMS, wherever applicable, to monitor the parameters across the AHU elements like filters, coil, fan, etc.

12) LIGHTING INSIDE THE AHU

Each section of the AHU shall be equipped with interior lighting. Interior lighting must be wet room execution, with a CFL lamp, terminal box and switch mounted on the unit's outside, wired and ready for operation.

13) INSTALLATION

The AHU shall be mounted PCC foundation as per the AHU manufacturer's recommendations/drawings. The AHU shall be rested on serrated rubber pads kept on top of the PCC foundation for vibration isolation.

14) CODES & STANDARDS

The design, materials, manufacture, inspection, testing and performance of the AHU's shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the equipment is to be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility. In particular, the AHU's shall conform to the latest edition of the following standards:

IS 7613	Methods of Testing panel type Air Filters for Air-Conditioning and Ventilation purposes.

ASHRAE 33	Methods of testing – Forced Circulation Air Cooling and Air Heating Coils
ARI 410	Forced circulation air –air cooling and air heating coils.
ARI 430	Central-station air handling units.
AMCA 210	Laboratory methods of testing fans for ratings.
NFPA 90 A	Installation of Air-Conditioning and Ventilation Systems.

15) FACTORY VIBRATION BALANCE REPORT

Certificate of compliance papers shall be attached to each fan at shipment, and signed by the fan manufacturer's quality control inspector. An additional copy shall be sent to Engineer in Charge.

- All factory balancing test results shall be furnished to certify the fan vibration does not exceed 50 mils per second rms for belt-driven units. Measurements shall be taken in a direction parallel to the shaft in a horizontal plane and in a direction perpendicular to the shaft in both the horizontal and the vertical planes.
- During balancing tests, the fan shall be operating at rated volume flow against the design external static pressure.

16) TESTING

Prior to shipment, AHU machines shall be subjected to inspection and witness of performance tests at the AHU manufacturer's works by the Engineer in Charge to verify various performance parameters as confirmed by vendor earlier at the time of award of contract. Performance test shall be carried out as per procedure laid down by AHRI and as per Engineer in Charge's specified parameter. The cost towards the travel and accommodation shall not be included in the bidder scope. The AHUs should not be despatched from the factory unless these have been witnessed and accepted by the Engineer in Charge on the performance.

17) PERFORMANCE DATA

Air handling units shall be selected for the lowest operating noise level of the equipment. Fan performance rating and power consumption data, with operating points clearly indicating shall be submitted and verified at the time of commissioning of the equipment.

18) VELOCITIES & SPEEDS

The air velocities, design parameters for the ducts and fan speeds for the air handling units are as follows;

Maximum face velocity across coils	:	500 FPM
Maximum fan outlet velocity	:	As Indicated in SOQ
Maximum fan speed	:	As Indicated in SOQ
Maximum fan motor speed	:	1450 RPM

Design parameter for duct design shall be:

Maximum flow velocity	:	1800 FPM
Maximum friction	:	0.1 inch WG/100 FT Run
Maximum velocity at supply air outlet	:	500 FPM

CHAPTER 7
VARIABLE FREQUENCY DRIVES

1) SCOPE

The scope of this clause comprises of design, supply, installation, testing and commissioning of BMS compatible Variable Frequency Drives with controllers conforming of these specifications and in accordance with the requirement of the Schedule of Quantities.

2) GENERAL REQUIREMENTS

- This specification covers complete variable frequency drives (VFDs)
- The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered product.
- The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.
- The VFD shall be tested to UL 508C. The appropriate UL label shall be applied.
- The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
- The VFD shall be UL listed for a short circuit current rating of 100 kA and labelled with this rating.
- The VFD shall have factory assembled C1 filter and harmonic filter

3) TECHNICAL REQUIREMENTS

The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor de-rating. When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

The VFDs shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

The VFDs shall have a dual 5% impedance DC link reactor (harmonic filters) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.

VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical. IEEE519, 1992 recommendations shall be used for the basis of calculation of total harmonic distortion (THD) at the point of common coupling (PCC). On request VFD manufacturer shall provide THD figures for the total connected load. The contractor shall provide details of supply transformer rating,

impedance, short circuit current, short circuit impedance etc. to allow this calculation to be made.

All VFDs shall contain integral EMC Filters to attenuate Radio Frequency Interference conducted to the AC power line. The VFDs shall comply with the emission and immunity requirements of IEC 61800-3: 2004, Category C1 with 50m motor cable (unrestricted distribution). The suppliers of VFDs shall include additional EMC filters if required to meet compliance to this requirement.

The VFDs' full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFDs shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

The VFDs shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed de-rating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was used at reduced speeds. Breakaway current of 160% shall be available.

A programmable automatic energy optimization selection feature shall be provided as standard in the VFDs. This feature shall automatically and continuously monitor the motors' speeds and load to adjust the applied voltage to maximize energy savings – AEO is part of VFD

The VFDs must be able to produce full torque at low speed to operate direct driven fans

Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFDs.

An Automatic Motor Adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test – AMA is part of VFDs

Galvanic isolation shall be provided between the VFDs' power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include Additional isolation modules.

VFDs shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFDs' operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.

The VFDs shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.

4) PROTECTIVE FEATURES

- A minimum of Class 20 I2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed
- Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFDs shall display all faults in plain language. Codes are not acceptable
- Protect VFDs from input phase loss. All VFDs should have protection from damage and indicate the phase loss condition. During an input phase loss condition, the VFDs shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
- Protect from under voltage. The VFDs shall provide full rated output with an input voltage as low as 90% of the nominal. The VFDs shall continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.
- VFDs shall include current sensors on all three output phases to accurately measure motor current, protect the VFDs from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFDs shall trip off and identify which of the output phases is low or lost.
- If the temperature of the VFDs' heat sink rises to 80 C, the VFDs shall automatically reduce the carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the temperature becomes too high
- In order to ensure operation during periods of overload, it must be possible to program the VFDs to automatically reduce the output current to a programmed value during periods of excessive load. This allows the VFDs to continue to run the load without tripping
- The VFDs shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFDs are running
- Protect from output switching: The VFDs shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode
- When used with a pumping system, the VFDs shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. The VFDs shall be programmable to take appropriate protective action when one of the above situations is detected

5) INTERFACE FEATURES

- Hand, Off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.
- There shall be an Info key on the keypad. The Info key shall include online context sensitive assistance for programming and trouble shooting.

- The VFDs shall be programmable to provide a digital output signal to indicate whether the VFDs are in Hand or Auto mode. This is to alert the Building Management System whether the VFDs are being controlled locally or by the Building Management System.
- Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.
- All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
- To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFDs's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFD's of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy Status
- Display shall be programmable to communicate English.
- A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFDs when the keypad is removed.
- A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFDs. The VFDs shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.
- A three-feedback PID controller to control the speed of the VFDs shall be standard.
- This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common set point or to individual set points and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.
- The VFDs shall be able to apply individual scaling to each feedback signal.
- For fan flow tracking applications, the VFDs shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.
- Each VFD's PID controller shall be able to actively adjust its set point based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.
- The VFDs shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide set point reset.
- Floating point control interface shall be provided to increase/decrease speed in response to contact closures
- Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others
- Programmable Sleep Mode shall be able to stop the VFDs. When its output frequency drops below set sleep level for a specified time, when an external

contact commands that the VFDs go into Sleep Mode, or when the VFDs detect a no-flow situation, the VFDs may be programmed to stop. When the VFD s speed is being controlled by its PID controller, it shall be possible to program a wake-up feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD

- A run permissive circuit shall be provided to accept a system ready signal to ensure that the VFDs do not start until dampers or other auxiliary equipment are in the proper state for VFDs' operation. The run permissive circuit shall also be capable of initiating an output run request signal to indicate to the external equipment that the VFD has received a request to run.
- VFDs shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in 0C, return air temperature in 0C, supply air temperature in 0C, CO2 concentration in ppm, pressure in bar, differential pressure in PSI etc.
- VFDs shall be programmable to sense the loss of load. The VFDs shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

- Standard Control and Monitoring Inputs and Outputs
  - Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry
  - Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.
  - Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.
  - Each relay shall have an adjustable on delay / off delay time.
  - Two programmable analogue inputs shall be provided that can be either direct-or-reverse acting.
  - Each shall be independently selectable to be used with either an analog voltage or current signal.
  - The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.
  - A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
  - The VFDs shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and trouble shooting.
  - One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFDs and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output. xi. It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications
  - It shall be possible to command all digital and analog output through the serial communication bus.

- Optional Control and Monitoring Inputs and Outputs
  - It shall be possible to add optional modules to the VFDs in the field to expand its analog and digital inputs and outputs.
  - These modules shall use rigid connectors to plug into the VFDs s control card.
  - Each VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.
  - Modules may include such items as:
    - Additional digital outputs, including relay outputs
    - Additional digital inputs
    - Additional analog outputs
    - Additional analog inputs, including Ni or Pt temperature sensor inputs
  - It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFDs.

- Standard programmable fire-fighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFDs shall display FIREMODE whenever in fire-fighters's override mode. Fire mode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

- A real-time clock shall be an integral part of the VFDs.
  - It shall be possible to use this to display the current date and time on the VFDs's display
  - Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter set points and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC based software to set up the calendar for this schedule
  - All VFD faults shall be time stamped to aid troubleshooting
  - It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.
  - The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log
  - The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

- The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:
  - Comparators for comparing VFD analog values to programmed trigger values
  - Logic operators to combine up to three logic expressions using Boolean algebra
  - Delay timers
  - A 20-step programmable structure

- The VFD shall include a Cascade Controller which allows the VFD to Operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters

6) SERIAL COMMUNICATIONS

The VFDs shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:

- Metasys N2
- Modbus RTU

VFDs shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFDs and logs of VFD operation through the USB port. It shall be possible to communicate to the VFDs through this USB port without interrupting VFD communications to the building management system

The VFDs shall have provisions for an optional 24 V DC back-up power interface to power the VFD s control card. This is to allow the VFDs to continue to communicate to the building management system even if power to the VFDs is lost

7) ADJUSTMENTS

The VFDs shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. They shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

Four independent setups shall be provided. Four preset speeds per setup shall be provided for a total of 16. Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds. Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds. An automatic start delay may be selected from 0 to 120 seconds. During this delay time, the VFDs shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.
Four programmable critical frequency lockout ranges to prevent the VFDs from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

8) OPTIONAL FEATURES

All optional features shall be built and mounted by VFD manufacturer as an inbuilt factory solution. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

9) SERVICE CONDITIONS

- Ambient temperature at full speed, full load operation with continuous drive rated output current:
- 10 to 45°C for ratings up to 90 kW without derating
- 10 to 40°C for ratings 110 kW and higher without derating
- Relative Humidity: 0 to 95%, non-condensing.
- Elevation: Up to 3,300 feet without derating.
- AC line voltage variation: + 10% of nominal with full output.
- VFD Enclosure protection: IP21.
- Side Clearances: No side clearance shall be required for cooling.
- All power and control wiring shall be done from the bottom.
- All VFDs shall be plenum rated.

10) QUALITY ASSURANCE

- To ensure quality, the complete VFD shall be tested by the manufacturer. The VFDs shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.
- All optional features shall be functionally tested at the factory for proper operation.

11) VFD CONFIGURATION SOFTWARE

The VFD manufacturer shall provide PC based software configuration for the VFDs. This software shall allow Engineer in Charge/User to setup, configure, document and diagnose the VFDs, in order to enhance the their functionality and to minimize the Engineer in Charge's/user's dependence on outside sources for both setup and maintenance. The software shall be a Windows based program for computers with Windows based operating systems.

Communication: The software shall be capable of communicating with the VFDs and the factory automation system by means of acceptable digital communications protocols.

Communication link between the VFD Control Panel and the BMS shall be provided to make all the status / parameters in the Logic Control Panel of VFDs. For this purpose, the HVAC Contractor shall provide all necessary hardware and software at the VFD control panel end to make available the data in any one of BacNet, Lon or ModBus protocols. The HVAC Contractor shall provide all engineering data such as address and data list, type of connection, baud rates, handshake, parity, etc. to the BMS Contractor. The HVAC Contractor shall also provide the looping / interlinking of the Pumps microprocessor based panels. The BMS Contractor shall provide all necessary hardware and software at the BMS end and also the interconnecting cable between the VFD panel and the BMS. In case of multiple makes / models of the pump panels, as many links as required for each make / model shall be provided by the

BMS Contractor and the HVAC Contractor shall loop each make / model's panels. The BMS Contractor shall use the engineering data provided by the HVAC Contractor to implement the communication link. The BMS supplier shall perform all engineering including and up to generation of graphic pages, reports, alarms, etc. to display the status / parameters.

12) CODES & STANDARDS

The design, materials, construction, manufacture, inspection, testing and performance of AC Drives shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also confirm to the latest applicable standards. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

13) DATA TO BE SUBMITTED BY VENDOR

Following data shall be submitted within the period specified in technical specifications, after placing the order, for the Engineer in Charge's approval.

- General arrangement drawings showing outline dimensions, cable entry openings, fixing / foundations details, weights and door openings.
- Front & Cross sectional views showing arrangement details of equipment and terminal and with a Bill of Material for all equipment.
- Schematic diagram indicating terminal number for external connections.
- Manufacturer's technical literature on various equipment supplied.
    - Wiring diagram of complete invertor. This shall be based on approved schematic diagram. The correctness of this drawing shall be the responsibility of the VENDOR.
    - Test certificates for the cabinet and all individual equipment and performance load tests shall be submitted at least 2 weeks before dispatch of equipment.
    - Operational and maintenance manuals shall be furnished with the equipment.
    - Detailed drawing of convertor showing layout of power semiconductors, fuses, heat sinks, cooling systems etc.,
    - Schematic diagram with detailed block diagram of gating circuits and control systems.
    - General arrangement drawing.
    - Operational and maintenance manual for the convertor.
    - Details of testing procedure for power semiconductors and power converters as per Standards / Code of Practice for approval.
    - Shipping details of the equipment.

CHAPTER 8
CHILLED WATER PIPING & HOT WATER PIPING

1) SCOPE

The scope of this clause comprises the supply and laying of heavy class pipes with bevelled ends, all pipe accessories such as bends, elbows, flanges, G.I nuts, G.I bolts, thermo-wells for temperature gauges, descaling tee, M.S. channel angle rod supporting work and PCC supports with full round high density PUF supports, vibration isolators and valves, testing and balancing of the piping system, required for the complete installation as shown in the drawings and in accordance with the requirement of the Schedule of Quantities. All piping inclusive of fittings and valves shall follow the Indian Standards. The scope includes excavation & refilling of earth in all types of soil including hard rock if any and cutting & remaking of existing footpath, roads etc.

2) PIPE SIZES

Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes have been indicated on the drawings, these are for contractor's guidance only and shall not relieve contractor of responsibility for providing pipes of proper sizes providing smooth noiseless balanced circulation of fluids and catering to the necessary cooling and heating loads.

3) BEVELLED ENDED CHILLED WATER PIPING & HOT WATER PIPING

- Chilled water and hot water shall be pumped through insulated chilled water pipes and insulated hot water pipes respectively. All pipes in AHU rooms shall preferably be supported off the floor and supporting the chilled water pipes off the ceiling shall be minimised to the extent possible so as to avoid transmission of vibration to roof ceiling slab and occupied floor above.
- Chilled water pipes & Hot water pipes shall be bevelled ended, ERW Mild Steel (MS) Class `C' (Heavy Class) conforming to relevant BIS-1239 Code and all the fittings also shall be of Mild Steel. Factory rolled pipes above 150 NB shall have maximum wall thicknesses as per IS 3589. All jointing in the pipe system shall generally be by welding, unless otherwise mentioned, or directed at site. All welding shall be done by qualified welders and shall strictly conform to BIS Code of practice for manual metal arc welding of Mild Steel.
- All welded joints (except pipe welded end-to-end) shall be made by use of forged one-piece welding flanges, caps, nozzles, elbows, branch outlets and tees of approved make. For pipes up to 200mm diameter, readymade pipe fittings shall be used. Fabricated fitting shall not be used for pipes up to 200mm. Cut samples shall be submitted for approval, if directed. All such fittings etc. shall be of a type which maintain full wall-thickness at all points, simple radius and fillets, and proper bevels or shoulders at ends. All job welding shall be done by the electric arc welding process.
- All joints shall have 45 degree bevel type, pipe mill-bevelled or machine-bevelled.
- All scale & oxide shall be removed with hammer, chisel/file & bevel left smooth and clean.
- Pipe lengths shall line up straight with abutting pipe ends concentric.
- Both conductors from the welding machine shall be extended to locations at which welding work is being done. The leads from welding machine to location of welding work shall be held together with tape or other approved means so as

to prevent induced current in structural steel, in piping or in other metals within the building. The ground lead shall be connected to length of pipe through joints in pipe, structural steel of building or steel pipe supports.

- All pipes and their steel supports shall be thoroughly cleaned and given two coats of primer and epoxy paint before being installed. For vibration isolators pre moulded polyurethane pipe sections of 160 Kg/m3 density with adhesive shall be fixed between pipe and MS support. 10 mm thick MS 'U' clamp shall be fixed on the pipe so that the pipe is kept in position. All welded piping shall be subject to the approval at site.
- Fittings shall be of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type. These shall form part of piping and are not separately identified in Schedule of Quantities.
- Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
- The underground Chilled Water Pipe shall be insulated with 50 mm thick TF quality expanded polystyrene thermocol thermal insulations with non-toxic CPRX adhesive wrapped with plasticized glassfibre RP tissue vapour barrier, tied with GI wire mesh, thereafter the pipe shall be sand cement plastered with 2 coats of 12 mm thick sand cement plastering & waterproofing with black tarfelt sheet protection and painted wherever required as per approved colours.
- The Hot Water Pipes shall be insulated with with pre-formed slab of 50 mm thick mineral wool of 100 kg/cu.m density covered with vapour barrier, tarfelt sheet, chicken wire mesh and Aluminium cladding of 24 gauge.
- Underground pipes shall be layed with sand bedding and covered with baked bricks on top pipes for protection.
- Above ground chilled water pipes shall be insulated with closed cell elastomeric nitrile rubber with factory laminated fire retardent fiber glass cloth for protection including all bends, fittings, flanges, etc. The closed cell Elastomeric nitrile rubber Thermal insulation material shall be of Class O fire rated as per BS 476 part 6 for fire propagation with adhesive of same grade.
- Above ground pipes shall be given 2 coats of primer and epoxy paint.

4) BUTTERFLY VALVES

Butterfly valves shall be of slim seal, short wafer type with standard finish. The valves shall be suitable for mounting between flanges drilled to ANSI 125. The valve body shall be cast iron and the disc shall be of ductile iron. The disc shall consist of disc pivot and driving stem. The disc shall move in bearings on both ends with 'O' Ring to prevent leakage. The seat shall be moulded black nitrile rubber or EPDM. The valves shall be suitable for a working pressure of 16 kg/sq.cm and shall be complete with flow control lever and notches, factory machined companion flanges, bolts & nuts. Valves above 200 mm dia shall be gear driven. The valves shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

5) PRESSURE INDEPENDENT 2 WAY MOTORISED FLOW CONTROL VALVE WITH ACTUATOR

Flow control valves (FCV) shall automatically control flow rates of chilled water entering the cooling coils with 5% accuracy. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and coil / helical spring to avoid corrosion. Contractor/ Manufacturer shall provide independent laboratory tests

verifying assurance of performance. All FCV shall be of one manufacturer and conform to the above specification. Valve shall be electronic, dynamic, modulating, 2 way, control device. Maximum flow setting shall be adjustable to 51 different setting within the range of the valve size. It shall be BMS compatible. The valves shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

Valve actuator housing shall be rated to IP44. Actuator shall be driven by 24 VDC motor and shall accept 2-10 VDC, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals. Actuator shall be capable of providing 4-20mA, 2-10VDC feedback signal to control system. Optional fail safe system to power valve to either open of closed position from any position in case of power failure shall be available. Extended LED read-out of current valve position and maximum valve position setting shall be standard.

6) VALVE HOUSING

Housing shall be ductile iron, ASTM A536-65T, class 60-45-18 rated 4000 kPa static pressure/forged brass ASTM B584 rated 2500kPa static pressure and 120°C.

7) MANUAL BALANCING VALVES

Double regulating globe valve type manual balancing valves shall be provided at various lines as indicated in the drawings and schedule of quantities. These valves shall have built-in pressure-drop measuring facility to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation. To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a computerised balancing instrument which shall enable the operator to read the flow directly without the use of diagrams or tables. In addition to measuring flow rate, differential pressure and temperature, computerised balancing instrument shall have a computer programme to provide the following functions:

- To balance the HVAC installation and calculate the necessary valve settings, based on system measurements.
- To store the results of balancing.
- To log measured values from a valve (differential pressure, flow rate or temperature).
- To print out saved data in computerized measurement protocol (CMP) consisting of:

- Name and size of Balancing Valve (BV)
- Presetting position of BV
- ΔP at BV
- Flow at BV
- Design Flow

The valves shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

8) NON RETURN VALVE

Non return valve shall be of C.I and be suitable for vertical pipeline / horizontal pipeline as per site requirement and inline with relevant IS, it shall be suitable for PN 16 bar service as specified and shall have safe operating range between 5 Deg. Centigrade and 55 Deg. Centigrade. The valve shall have flanges. If a disc or plate type valve is used then it's disc shall be of stainless steel grade SS 304 and it shall have a spring of Stainless Steel and the Seal shall be of EPDM elastomer. The valves shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

9) STRAINERS

Strainers shall be of cast iron body. Strainers shall incorporate a removable SS-316 screen with 3mm perforations and a permanent magnet. Strainers shall be provided with matching flanges at both ends for connecting with the chilled water pipes & hot water pipes. They shall be designed to enable blowing out the accumulated dirt and facilitate removal / replacement of screen without disconnecting the main pipe. The types of the strainers are as specified in the SOQ. The strainers shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

10) MOTORIZED 3 WAY MIXING VALVES

3 way mixing valves shall automatically control flow rates of hot water entering the heating coils with 5% accuracy. These valves shall have sensor, controller an actuator for controlling the flow of hot water. The valves shall be insulated with the same insulation as the adjoining pipes and with the same thickness.

11) FLANGES & UNIONS

Sufficient number of flanges and unions shall be provided as required to facilitate the maintenance work after the piping is installed. Mild steel ANSI 125 flanges shall be used for pipes of 65mm dia and above. Flanges shall be of approved make. The supply of flanges shall form part of piping (not separately identified in Schedule of Quantities) and shall also include supply of bolts, washers, nuts and suitable asbestos fibre / rubber insertion gaskets (min 3 mm thick).

12) PRESSURE GAUGES AND TEMPERATURE GAUGES

- Both pressure gauge and Temperature gauges shall be made of stainless steel body and stem. The gauges shall be weather proof and water proof. The valve shall have the accuracy of +/- 1% of the reading
- Pressure gauges' dial shall be not less than 150 mm dia. They shall be selected for appropriate range and shall be complete with siphon and cock, etc. Pressure gages as specified shall be provided at chilled water and hot water supply and return at each air handling units. Care shall be taken to protect pressure gages during testing. Pressure gage sockets on insulated pipes and accessories shall be extended up to insulation to avoid damage of insulation for replacement of gages.
- Temperature gauges' dial shall not be less than 150 mm dia. These shall be of thermo-well type and as specified shall be provided at chilled water and hot water supply and return at each air handling unit. Temperature gauges shall be with long stem. Their socket shall be extended up to insulation thickness so that they can be removable without damaging the insulation.

13) CHILLED WATER EXPANSION TANK

- The expansion tank shall be of 6 mm thick M.S plate construction. The expansion tank shall be complete with safety relief valve, pressure reducing valve, float valve, water level indicator, lockable door cover top, overflow arrangement, quickfill, make-up connections, drain valve and pressure gauge. The quoted price shall be inclusive of structural support for the tank.
- It shall be insulated with 50 mm thick “TF” quality expanded polystyrene (thermocol) covered with 24 G Al sheet as a mechanical protection.
- The internal surface of the tank shall be coated with anti corrosive paint.

14) AIR VENT VALVE

The float shall be of synthetic material and shall keep the venting valve closed under normal condition. When air is collected inside the float chamber, the water level inside the auto air vent shall decrease and the venting valve shall be opened. The collected air then shall escape through the venting valve and the water level inside the float chamber shall increase again, closing the venting valve. This process shall continue as long as air is collected in the float chamber. There shall be a check valve at the bottom to seal the system when the auto air vent is removed for servicing.

15) MAKEUP WATER AND DRAIN PIPING

- All pipes to be used for makeup water, drain, condensate drain and fittings shall be galvanized steel class `B’ (medium class) conforming to relevant BIS Codes.
- All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.
- Fittings shall be galvanized steel `medium class’ malleable casting of pressure rating suitable for the piping system. Flanges shall be of approved make. Supply of flanges shall include bolts, nuts, and gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified in Schedule of Quantities.
- Valves, strainers shall be similar to those specified for chilled water piping.
- For proper drainage of AHU Condensate, ‘U’ trap shall be provided in the drain piping.
- All condensate drain piping shall be insulated with 9mm thick closed cell nitrile rubber with black glass cloth lamination in pipe section.

16) MAGNETIC TYPE FLOWMETERS

Supply, installation, testing and commissioning of Magnetic type flow meters for measuring the flow in chilled water pipes and hot water pipes. The capacities of the Magnetic type flow meters shall be as indicated in the Schedule of Quantities and their selection shall be as per relevant Indian Standards. The Magnetic type flow meters shall be tested at Manufacturer’s works as directed by Engineer-In-Charge.

17) PIPING INSTALLATION

- Design drawings indicate schematically the size and location of pipes. The Contractor, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in the building through which pipes are designed to pass.
- Piping shall be properly supported on or suspended from stands, clamps and hangers as specified and as required. The Contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency.
- Pipe supports shall be of steel, adjustable for height and primer coated with rust preventive paint and finish coated black. Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following :

Pipe size	Spacing between supports	Rod Size
15 to 25 mm	2.0 meter	8 mm
30 to 125 mm	2.0 meter	10 mm
150 mm & above	3.0 meter	MS Channel

- Vertical pipes passing through floors shall be plumb and parallel to wall. Pipes shall be supported on each floor. U clamps with vibration isolation sheet between the pipe and M.S Support shall be provided to keep the pipe in position.
- Bull heading in piping shall be avoided.
- Pipe sleeves at least 3 mm thick, 50 mm / 100 mm larger in diameter than respective pipes respectively shall be provided wherever pipes pass through retaining wall and slab. Annular space shall be filled with fibreglass and finished with retainer rings welded on the ends of the sleeve.
- Wherever pipes pass through the brick or masonry / slab openings, the gaps shall be sealed with fire barrier caulks.
- Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20G metal sheet shall be provided between the insulation and the clamp, saddle or roller, extending at least 15cm on both sides of the clamp, saddles / roller.
- All piping work shall be carried out in a workman like manner, causing minimum disturbance to the existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.

- Cut-outs in the floor slabs for installing the various pipes are indicated in the Drawings. Contractor shall carefully examine the cut-outs provided and clearly point out where the cut-outs shown in the Drawings do not meet with the requirements.
- The Contractor shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.
- All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges bevelled and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.
- Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided where-ever shown in Approved-for-Construction shop drawings, to facilitate future cleaning of all welded pipes.
- Insulated buried pipes shall be cleaned, de-rusted, then coated with rust-resistant primer and placed on concrete blocks with PUF saddles dipped in bitumen at every 2.5 meters. Insulation shall be applied as per the “Insulation” Clause, wrapped with GI wire and covered with polyethylene sheet. Two coats (each 6 mm thick) of cement plaster shall be applied over chicken wire mesh lath. All buried insulated pipes shall be water-proofed using coat of Shalibond, or approved adhesive, over the plastered surface; wrapping one layer of fibre glass RP tissue and one layer of roofing tarfelt with sufficient overlaps, set and sealed with the adhesive, held in position by 16 gage G.I wire tied at 15 cm intervals.
- Auto purge valves shall be provided at all points shown in the drawing in the piping system for venting air. Air valves shall be 15 mm pipe size with screwed joints
- Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.
- All chilled water piping and hot water piping and their fittings shall be pressure tested, painted and then insulated as described under the “Insulation” Clause.
- All pipes supports shall have vibration isolation arrangement.
- Necessary sockets and nipples with suitable brass thermowell for mounting sensors / transmitters on pipe line to interface the BMS system.

18) TESTING

- During construction, the contractor shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.
- All piping shall be tested to hydrostatic test pressure of at least two and half times the maximum operating pressure, but not less than 10 kg/sq.cm gage for a period of not less than 48 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved.

- Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.
- Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.
- The Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by the Engineer in Charge.
- The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils in the system concerned. If proper circulation is not achieved due to air bound connection, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out all the above rectifications including the tearing up and re-finishing of floors and walls if required.
- After the piping has been installed, tested and run for at least three days of eight hours each, all insulated exposed piping shall be given two finish coats, 3 mils each of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to Insulation section.
- Before handover the Engineer in Charge shall be provided with certificate of cleaning of pipe systems, signed by the Contractor.
- The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the tests.

19) BALANCING

- After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.
- All balancing valves, Automatic control valves and two-way diverting valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted thru balancing valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed.
- Complete certified balancing report shall be submitted for evaluation and approval by the Engineer in Charge. Upon approval, four copies of the balancing report shall be submitted with the as-installed drawings and completion documents.

20) VALVE IDENTIFICATION

Provide 30 mm dia brass valve tag, with embossed letters and number for each valve and attach the tag to valve handle by “S” hook or by suitable means. Contractor shall provide valve tag schedule and valve chart for each piping system, consisting of schematic drawing of piping layout, along with a valve list, showing and identifying each valve by number, service and location and describing its function. Tags shall correspond with the valve schedule and record drawings.

CHAPTER 9
AIR DISTRIBUTION SYSTEM

1) SCOPE

The scope of this clause comprises the design, supply, fabrication, installation, testing and commissioning of Sheet Metal Ducts and Dampers and the supply, installation, testing and balancing of Grilles and Diffusers in accordance with these specifications and the General Arrangement shown on the Drawings and in accordance with the requirement of the Schedule of Quantities. The air distribution system shall be designed to convey correct quantities of conditioned air to provide the design air flow rate and environmental condition, while maintaining suitable area pressurization requirement within the conditioned space.

2) SHEET METAL WORK (DUCT WORK)

The Contractor shall supply, fabricate, install and test all metal duct works complete with air balancing and commissioning as shown in drawings. The tender drawings are not meant as working drawings. On the award of contract, the contractor shall prepare his own detailed working drawings sizing by equal friction method. All such working drawings shall be got approved from the Department. The duct work shall commence only after such approval is obtained from the Department or Engineer in charge even after the approval, the contractor shall be responsible for performance of the system.

3) DUCT MATERIALS & SIZES

All ducts shall be fabricated with zinc coating and Lock Forming Quality prime material along with mill test certificates. GI sheet metal shall conform to IS:277 with a zinc coating grade of 180GSM (both side inclusive) and aluminum sheets conforming to IS:737, Grade 31000. All fasteners shall be galvanized. The duct construction shall conform to IS 655 and the sheet metal thickness to be used for various duct dimensions shall be as under:

Longest Side (mm)	Minimum Sheet Gauge
	Material : G.I
Up to 300	24
301 to 1500	22
1501 to 2250	20
2251 and above	18

Supporting of Ducting shall be provided by the Air Conditioning Contractor, it shall be generally supported from Roof Slab, Beams, Bottom Members of Truss and OR Additional MS Structural frame work as per the site conditions. MS Angles and threaded rods shall be utilized for supports. Further, anchor grip bolts shall be utilized wherever the supports are to be taken from concrete members. The support MS Structures should be duly painted with two coats on zinc chromate primer and two coats of black enamel paint. The spacing of hangers shall be as per IS:655.

4) DUCT CONSTRUCTION

The duct shall be designed as per “equal friction method” as far as possible. All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant codes.

i. Ducts shall be acoustically lined and insulated from inside for a distance of 5 meters from the AHUs as described in the “Insulation” Clause and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.

ii. Ducts shall be straight and smooth on the inside with longitudinal seams. Ducts shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness.

iii. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence.

iv. Ducts shall be fabricated as per details shown on approved drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

v. All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.

vi. Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside.

vii. Self adhesive Neoprene rubber / UV resistant PVC foam lining of 5 mm nominal thickness instead of felt shall be used between duct flanges and between duct supports in all ducting installation.

viii. All ducts shall be installed generally as per tender drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor. The contractor shall also carry out the feasibility study at site, coordination with other services and interior drawings before fabrication of duct. Any fabricated duct rejected due to these reasons shall not be paid and only final measured and installed duct shall be certified for payment.

ix. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of the Engineer in Charge in all its parts and details.

x. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown in the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.

xi. If a duct cannot be run as shown on the Drawings, the Contractor shall install the duct between the required points by any path available, in accordance with other services and as per the approval of the Engineer in Charge. Fabrication of duct shall be commenced only after verifying the feasibility at site.

xii. All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel under ducts at no greater than 2 meter center to center. Vertical duct work wherever present shall be supported by structural members on each floor slab. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles/ channels shall be hung through these cleats. Duct support shall be through dash /anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

xiii. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling.

xiv. Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with mortar for complete sealing. Contractor shall ensure that contact between metal duct and mortar is avoided.

xv. All ducts shall be totally free from vibration under all conditions of operation.

xvi. Duct shall not rest on false ceiling and all the supports shall be provided from slab only.

xvii. Suitable arrangement shall be provided in duct for fixing of duct smoke sensor (supplied by other vendor).

xviii. Toilet exhaust duct shall be provided with goose necking as shown in drawings and exhaust shall continue operation in case of fire.

xix. PVC washers shall be provided at two different metallic joints to avoid bi-metallic corrosion.

xx. The duct fabrication and installation shall generally conform to IS 655-1963. The Contractors shall provide and neatly erect all sheet metal work as shown on drawings as may be required to carry out the intent of these specifications and Tender drawings.

xxi. All joints shall be made air tight and all interior surfaces shall be smooth. Bends shall be made with radius not less than one half the width of the duct or with scientifically designed interior curved vanes, as approved. The vane shall be so placed that the aspect ratio of each of the individual elbow formed by the vanes will be about five.

xxii. Where metal ducts or sleeves terminate in woodwork, brick or masonry openings, air tight joints shall be made by means of closely fitted heavy flanged collars.

xxiii. Doors shall be set in ducts and air plenums for access to pipes dampers, coils, valves, etc. Doors shall be provided with suitable latches. All access doors in the duct work shall be air tight.

xxiv. Air handling units shall be connected to duct work by inserting at air inlet and air outlet double canvas sleeve. Each sleeve shall be 100 mm long minimum securely banded and bolted to duct and units. Each sleeve shall be made smooth and the connecting duct work rigidly held in line with unit inlet or outlet.

xxv. Duct shall be supported by means of painted MS rod or angle (min. 12 mm dia) or angle suspenders hung from RCC slab by means of expansion bolts or anchor fasteners min. 12 mm dia.

5) VOLUME CONTROL DAMPERS

- All duct dampers shall be opposed blade multi louvered dampers of robust 16G construction and tight fitting. The body frame shall be fabricated out of extruded Aluminium/GI section and blades fabricated out of aerofoil AI section. The design, method of handling and control shall be suitable for the location and service required.
- Dampers shall be provided with suitable gears/links/levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
- Dampers shall be placed in ducts as indicated in the Drawings, for the proper volume control and balancing of the air distribution system.

6) DIFFUSERS AND GRILLES

Diffusers/Grilles shall be made of powder coated extruded aluminum construction. All the grilles and diffusers shall be provided either with integrated volume control dampers or with separate volume control dampers, along with all the accessories required for proper assembly between grills/diffusers and their dampers. The painting on the grilles and diffusers shall be as approved by Engineer-in-charge.

- Supply and return air diffusers and grilles shall be as shown in the Drawings. The diffusers & grilles shall be powder coated & made from extruded aluminum section.
- Supply air diffusers/grills shall be provided with volume control dampers for all air-conditioned areas. Return air diffusers/grills of air conditioned areas shall also be provided with volume control dampers. Diffuser neck velocities shall be restricted below 2 m/s.
- Diffusers with flush fixed pattern for different spaces shall be selected in consultation with the Engineer in Charge. These shall be procured only after obtaining written approval from the Engineer in Charge for each type of diffuser.
- Supply air diffusers and grilles shall be equipped with fixed air distribution grids, removable key-operated volume control dampers, and anti-smudge rings. All extruded aluminium diffusers shall be provided with removable central core and concealed key operation for volume control damper.
- Design of all diffusers and grills shall be matching with the lighting fixture, false ceiling and other fittings. Prior approval of Engineer in Charge shall be obtained for the location, type & colour code of diffusers/ grills.

7) TESTING

After the ducting insulation is completed, all duct system shall be tested for air leakage, structural arrangement and joint air tightness. The contractor shall test all the ducting, joints and others very carefully in the presence of Engineer-in-charge or his representative in accordance with the test procedure approved by the Engineer

in Charge. Any test without Engineer-in-charge's approval will be treated as null and void.

The entire air distribution system shall be balanced to supply air quantities as designed for various regions and rooms to maintain the specified room conditions. The final balance of air quantities through each grill, register or diffuser shall be recorded, submitted to the Engineer-in-charge for approval. Air Balancing operation shall be supervised by Engineer In Charge who shall be present at the job site continuously for such work.

The volume of air supplied at every grill shall be determined by the use of revolving vane anemometer and shall be used along with the stop watch to determine average velocity over the grill face. The louver setting of the grills and deflection shall be fixed as to provide most uniform, draft-less distribution over the entire area served. Anemometer calibration correction factor and grill flow rate factor shall be taken into account while computing air delivery.

8) PAINTING

Ducts, hangers, supports, diffusers and grilles wherever required shall be painted with two coats of approved epoxy paint over epoxy primer.

9) FIRE/SMOKE DAMPERS

- Fire/Smoke dampers shall be provided as shown in the drawings, to prevent spread of smoke / fire to the adjoining areas.
- The dampers shall be electrically operated and of at least 90 minutes rating as per UL555/1995 certified by UL. These shall be of multi-leaf type and provided with Spring Return electrical actuator having its own thermal trip for ambient air temperature outside the duct and air temperature inside the duct. Actuator shall have form fit type of mounting, metal enclosure and guaranteed long life span. The damper shall shut automatically in case of power failure.
- The damper shall be made out of 16G thick galvanized sheet steel frame and blades of 18G galvanized steel with air tight arrangement. Fire damper shall be fitted with 18 gage extended sleeves on both sides. The damper blade shall be pivoted on both ends using chrome plated spindles in self lubricated bronze bushes. Stop seals shall be provided on top and bottom of the damper housing made of 16G galvanized sheets steel. For preventing smoke leakage metallic compression seals will be provided.
- Each damper shall be provided with control panel, actuator, smoke / heat sensor and transmitters, control cables, communication cables, etc.
- The electric actuator shall be energized upon receiving a signal from smoke detector. The fire damper shall also close upon sensing temperature rise in supply air ducts through the electronic temperature sensor. The actuator shall also have manual operation feature and key for manual operation shall be provided for each actuator.
- Each damper’s control panel shall mounted on the wall within the AHU room and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
    - Potential free contacts for AHU fan ON/ OFF and remote alarm indication.

- Accept signal from external smoke / fire detection system for tripping the electrical actuator.
- Test and reset facility.
- Indicating lights / contacts to indicate the following status:
- Power Supply On
- Alarm
- Damper open and close position.
- The control panel shall be suitable for receive/send signal from the Fire Alarm System and status shall be monitored through BMS.

- Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each motor operated damper in conjunction with it's control panel. Control panel shall be wall mounted type and located in AHU room or nearest electrical room.
- It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.
- HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energising all the smoke detectors with the help of smoke.
- HVAC Contractor shall provide Fire retardant cables (FRLS) for satisfactory operation and control of the Damper.
- HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site. Installation of damper shall be as per manufacturer recommendation or as per Engineer in Charge's Instructions. Damper shall be provided with GI sleeves extending on either side of wall up to 3 inches to 6 inches. The damper shall be supported with structural wall by providing 32 mm x 32 mm angle frame on all sides of sleeve. Damper shall be supported with structure using a fastener. Installation details in form of sketch shall be submitted prior to execution and gotten approved from the Engineer in Charge.
- Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts in accordance with the manufacturer's recommendations. The location of actuator shall not foul with the fire rated wall. However, damper shall be placed on the fire rated wall.
- Filling-up the annular gap between wall and duct / smoke damper with fibre glass and applying fire sealant.

10) TESTING AND BALANCING

After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection. The entire air distribution system shall be balanced using an anemometer. Measured air quantities at fan discharge, at various outlets and return air shall be identical to or less/excess than 5 percent in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted for scrutiny and approval, and four copies of the approved balance report shall be provided with completion documents.

CHAPTER 10
INSULATION

1) SCOPE

The scope of this clause covers the supply and application of insulation of various types of insulation materials with various types of application as specified in the drawings and in accordance with the requirement of the Schedule of Quantities, for sheet metal ducting, chilled water piping & hot water piping, drain pipes, etc.

2) DUCT INSULATION

Insulation material for Duct thermal insulation shall be 25 mm closed cell Elastomeric Nitrile Rubber with factory laminated fire retardant fibre glass cloth protection and having anti-microbial protection. The anti-microbial product protection shall be an integral part of insulation that is built-in during the manufacturing process and the product protection should not allow the microbes to function, grow and reproduce. The closed cell Elastomeric nitrile rubber thermal insulation material shall be of Class O fire rated as per BS 476 part 6 for fire propagation with adhesive of the same grade. The longitudinal and transverse joints shall be sealed with self adhesive tape of same material.

Insulation material for Duct Acoustic Lining shall be 15 mm thick processed Open cell Nitrile Rubber foam having anti-microbial protection. The material should be dust and fibre free. The density shall be within 140-180 Kg/m3. Ducts shall be provided with acoustic lining for a distance of minimum 5 meters from AHU Plenums. The inside surface for the ducts shall be covered with adhesive recommended by the manufacturer. Cut Foamed sheets into required sizes apply adhesive on the foam and stick it to the duct surface. The material shall conform to Class 1 rating for surface spread of flame as per BS 476 Part 7.

Thermal conductivity of duct insulation (Closed Cell as well as Open Cell Nitrile Rubber Insulation) shall not exceed 0.038 W/m^{o}K at an average temperature of 20°C. The product shall have temperature range of –20°C to 105°C. The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class ‘O’ Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990. Water vapour permeability shall not exceed 1.74 x 10^{-14} Kg/m.s.Pa, i.e. Moisture Diffusion Resistance Factor or ‘μ’ value should be minimum 10,000 according to EN 12086.

3) INSULATION - APPLICATION

Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut the insulation sheets to size with sufficient allowance in dimension. Material shall be fitted under compression and no stretching of material shall be permitted. A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations. The adhesive shall be strictly as recommended by the manufacturer.

Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values and density. Samples of insulation material from each lot delivered at site may be selected by the Engineer in Charge and gotten tested for thermal conductivity and density at the Contractor's cost. All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

4) PIPING INSULATION

All above ground chilled water pipes and condensate drain pipes shall be insulated with closed cell nitrile rubber insulation (thicknesses are specified in the SOQ) in the manner specified herein. **All Hot Water Pipes** shall be insulated with 50 mm thick mineral wool thermal insulations, with minimum density of 100 kg/m^3 and provided with, covered with vapour barrier, tarfelt sheet, chicken wire mesh and cladding of 24 gauge Aluminium. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc. Nitrile Rubber insulation shall be applied as follows:

- Insulating material in tube form shall be sleeved on the pipes.
- On existing piping, pre-slited insulating material shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer.
- Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.
- Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.
- The insulation shall be continuous over the entire run of piping, fittings and valves.
- All valves, fittings, joints, strainers, etc. in chilled water piping and hot water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.
- The covering should be cut to size according the circumference of the insulated pipe allow an additional 50mm for the overlap of the covering material. The Overlap shall be securely fixed using recommended Adhesive.
- Spread thin film of recommended type on the 50mm overlap and close the seam. When covering fittings, the manufacturer's application manual shall be consulted. All fittings have to be covered to the same standards as the covering of the pipe work.

The closed cell nitrile rubber insulation material shall have a minimum density of 32 kg/m3 and thermal conductivity at 0ºC mean temperature shall not be less than 0.025 K.cal/hr mºC. The material shall be thermally stable (at least up to 100ºC). It shall be fire retardant type with Class O fire rating self-extinguishing, CFC free, non-dripping type.

The underground chilled water pipes shall be insulated with 50 mm thick TF quality expanded polystyrene thermocol thermal insulations with non-toxic CPRX and wrapped with plasticized glassfibre RP tissue vapour barrier, tied with GI wire mesh, thereafter the pipe shall be sand cement plastered with 2 coats of 12 mm thick sand

cement plastering & waterproofing with tarfelt sheet protection and painted wherever required as per approved colours.

The hot water pipes shall be insulated with 50 mm thick mineral wool thermal insulations, with minimum density of 100 kg/m^3 and provided with, covered with vapour barrier, tarfelt sheet, chicken wire mesh and cladding of 24 gauge Aluminium.

The insulation for chilled water pipes shall be covered with treated woven glass cloth cover material which has resistance to Scratch & Mechanical Impact.

5) PIPE SUPPORT

Insulated pipe support, single piece with self-adhesive closure, PUR/PIR load bearing Insert (Density 140 -180 kg/m^3) embedded in elastomeric nitrile rubber insulation with two outer metal shells made of aluminium sheet, which also acts as a vapour barrier for the PUR/PIR inserts. (Make: Armaflex or equivalent)

6) RECOMMENDED ADHESIVE

In all cases, the manufacturer's recommended Adhesive should be used for the specified purpose. Wherever, the pipes/ducts have exposed installation, an adhesive "Mastic" shall be applied on the overlapping of glass cloth.

7) PUMP INSULATION

Pumps shall be insulated with the same material and to the same thickness or more as the pipe to which they are connected to give proper shape of the pump. Care shall be taken to apply insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

8) EXPANSION TANK INSULATION

Chilled water expansion tank shall be insulated with minimum 19mm thick closed cell nitrile rubber as per manufacturer's standard.

9) PROTECTIVE COATING OVER INSULATION

To provide mechanical strength and protection from damage & UV rays all exposed duct insulation as indicated in SOQ shall be covered with woven glass fabric cloth. The glass fabric shall be applied with one coat of fire proof epoxy or acrylic compound. The coat shall be allowed to cure to non stick state. Subsequently second coat of compound shall be applied to give a tough and smooth finish to the insulated surface.

CHAPTER 11

CPM & BMS/BAS

CLAUSE 1.0 CHILLER PLANT MANAGER

1.1 SCOPE:

The Scope shall include Supply, installation, testing and commissioning of chiller plant manager(CPM) for the proposed chiller plant. The chiller plant includes water cooled /air cooled chillers- (qty as per SOQ), constant flow or variable flow or both chilled water pumps (qty as per SOQ), motorized valves on chilled water inlet and outlets etc. All the field equipment like temperature sensor, pressure sensor, level switch, etc and required length of communication cable/signal cable/control cable/power cable shall be included in the quoted rate. The rate shall also be inclusive of integrator for transferring the data available on the chiller plant manager (CPM) to HVAC automation (BAS) system and third Party BMS for remote monitoring & operation. All the parameters available on the CPM should have provision for transfer to the BAS system. It shall have provision for monitor and control the system and to alter the set point/ Vary/ Switch ON/ OFF Scheduling of equipment as minimum parameters to BAS system. The rate shall be inclusive of a latest configuration PC (Computer) in control room.

NB.: Any other item which is not specified and required for functioning of the chiller plant shall be included in the quoted rate and no extra payment shall be made for the same.

1.2 GENERAL:

A Chiller Plant Manager (CPM) system will be included with the chillers (where specified) to provide coordinated chiller plant operation, optimize energy efficiency, equipment protection with alarms, and all other requirements of a central chilled water plant. The CPM will also serve as an essential chiller management tool for owner personnel. This specification details specific features and functional requirements of the CPM System. In addition and priced separately, the CPM System shall be capable of controlling all central plant equipment, if so specified.

1.3 ACCEPTABLE SUPPLIERS:

The Chiller Plant Manager (CPM) and Packaged Chiller shall be supplied by same manufacturer.

1.4 SUPPLIER RESPONSIBILITIES:

The chiller manufacturer will be responsible for CPM System hardware, sensors, installation, programming, wiring, start-up, submittal, project documentation, warranty, and all other provisions of this specification. The chiller manufacturer will comply with the provisions of this specification as a requirement to be an acceptable supplier of the chillers and the CPM System.

1.5 BID SUBMITTAL:

The following Bid Submittals are required for an acceptable proposal of the CPM System:
CPM Equipment Dimensions
Chiller Plant Sequence of Operation CPM software description and operation CPM Equipment Data Sheets
Monitoring and Control Points List (indication of equipment to be installed by others)
RS-232 / RS 485 Compatibility Specification and Instructions
Installation List, with at least 30 installed systems Exceptions and deviations from specification

1.6 CPM HARDWARE:

The CPM System must be a microprocessor based programmable controller with the capability of specific chiller plant control, chiller interface, and operator use. The CPM will be designed to operate in a IP42/equivalent for indoor hardware or IP54/equivalent for outdoor hardware and must be U.L. approved.

Inputs - The CPM will have inputs for accepting signals from temperature sensors, pressures sensors, flow meters, chiller power use, equipment status, etc. The CPM must be capable of using analog inputs 0 to 10 volts DC, 4 to 20mA, digital switch closure, and pulse width signals. The chiller manufacturer will be responsible for selecting the appropriate method of system inputs and monitoring. Input quantity shall all be a minimum of four (4) inputs on up to 48 inputs according to the controller specified.
Outputs - The CPM will control the chiller plant using Direct Digital Control (DDC). The CPM outputs must be capable of modulating/positioning valves, chiller control vanes,

pump speed, fan speed, and other devices. The CPM must be capable of both analog control 0 to 10 volts, digital switch closure rating of 24VAC, and pulse width modulation. The chiller manufacturer will be responsible for selecting the appropriate method of control. Output quantity to be minimum of nine (9) and a maximum of twenty-four (24) in a specified controller.
HOA – Hand/Off/Auto Switch - All CPM outputs must have Hand-Off-Auto (HOA) switch for manual override of the system and indicating light(s) for output status.
Communication Data Port - The CPM must have an RS-232 data port for communication to a printer, terminal, or PC. The data port must use standard industry ASCII communication protocol, selectable 300 to 9600 baud synchronous communication speed. RS-485 must be used for the LAN (Local Area Network) communication port.
Communications to Other Building Automation Systems - The CPM will have a translator capability included that will transfer all inputs, alarm conditions, safety/cycling information to the BMS. The translator shall broadcast in 0 to 10VDC signals. These signals are to be generic and not require special protocols.
The supplier of the BMS shall be responsible for the connections to the CPM Translator. Any special signal conditions needed by the BMS supplier are to be provided in their portion of these specifications.
The translator shall be capable of receiving commands from the BMS to request information on each device controlled by the CPM and to change set points, alarm points, on-status of the chillers, maximum demand of each chiller, and parameters

as recommended by the chiller manufacturer. In no case shall the translator accept an improper command that will make the chillers operate at poor efficiencies or be subject to possible damage.
RS-232 Translator - The CPM will have an RS-232 Translator for equipment control interface to third party BMS via RS-232 ASCII protocol communication.
Communications to remote Service/Control Stations - The CPM will have the ability to communicate via a modem to a remote station. The remote station shall not require a terminal or computer to receive information. However, such terminals shall also be capable of being used if desired by the owner and included in this specification.

1.7 OPERATOR DISPLAY AND INTERFACE:

The CPM must have a display panel for human interface, on-site access to chiller plant operating data, enunciation of system alarms and messages, and changes in chiller plant control. The operator display shall be built-in. The CPM System must have the following features:

Keypad - Must have twenty (20) keys allowing access to all functions of the system; access of all chiller system temperatures, pressures, flows, calculated values, and equipment status. Also, change of chiller set point, chiller lead/lag selection, pull-down demand limit, chiller plant operating schedule, and other parameters as recommended by the chiller manufacturer for optimize chiller plant operation.
Display - The CPM System display shall be a built-in display with a two-line digital display of forty (40) characters per line and must be capable of displaying system temperatures, pressures, flows, calculated values, equipment status, valve position, system alarms, and messages.
Other Features - The CPM System must have an audible means to enunciate system alarms by use of a beeper or horn in conjunction with the flashing alarm indication on the display screen.

1.8 SENSORS AND INTERFACE DEVICES:

The chiller manufacturer shall provide all sensors and interface devices for the CPM System. All sensors and devices shall be of the highest quality and reliability while meeting the following accuracy and specifications for proper chiller plant operation.

Temperature Sensors - Temperature sensors shall be platinum or nickel RTD or thermistor also must be mounted in a separable well. Temperature sensor accuracy must be less than 1% over application range and at least +/–1/4□F accuracy. Differential temperature sensors for chilled water temperature and load calculations must be 1□F accuracy.
Other Sensors and Devices - Water pressure sensors, chiller kW/amp sensors, and refrigerant pressure sensors shall be 1% accuracy over the application range. All sensor mounts and fittings will be supplied by the chiller manufacturer and installed in the factory. System input sensors that are mounted in the field shall have piping installed by others. Water valves and operators will be supplied by others unless otherwise noted which then will be electric or pneumatic and interfaced with the CPM System. The chiller manufacturer will approve valve operator vendors per specification. The mechanical contractor will install all valves in the piping as shown on drawings.

Auxiliary Panels - The chiller manufacturer will provide any auxiliary panels for interface devices, where needed.
Chiller Control Panel Compatibility - The CPM System and interface devices shall tie into the chiller control panel without override to its operating control and safety integrity and shall be installed by the chiller manufacturer unless otherwise noted. In the event of CPM panel failure, the microprocessor on the chiller unit shall provide English read- out and shall be completely capable of controlling itself at the last command set point issued by the CPM System.

1.9 CPM SOFTWARE:

The CPM System must have operating system software with specific features, capabilities for proper chiller plant control and future customer requirements. The CPM software will be preprogrammed with provisions for customer programmability plus custom control features to match all requirements. Canned programs without total flexibility for customer needs are not acceptable.

Control Algorithms - The CPM must be capable of P, PI, and PID (Proportional-Integral-Derivative) control for chilled water temperature control, and condenser by-pass valve control, cooling tower fan control, chiller loading/unloading control, pump control, and other control algorithms. Set point, offsets, and rate factors must be adjustable for fine-tuning and chiller plant control stability.
Decision Logic - The CPM must be able to make logic control decisions for intelligent chiller plant control decisions based on various operating conditions. The software must be able to perform comparisons, if then, greater than, less than, equal to, and similar logic decisions.
Equation Processor - The CPM software must incorporate a means to do mathematical equations for calculating chiller plant variables and chiller operator information. Totalizing the date is also an essential requirement.
Clock/Calendar - The CPM software and control algorithms must incorporate an uninterruptable real time clock capable of time of day, month, year, and day of week.
English Commands and Messages - The CPM software must use English commands for system programming and operator commands. The software must also be capable of displaying/printing messages, alarms based on chiller plant operating conditions, and operator input in English.
Security Access - The CPM software must have at least three (3) levels of password security to allow access to information only, limited chiller plant control changes, and CPM reprogramming respectively.
Historical Data - The CPM software must be capable of accumulating historical data and equipment logs. The CPM must have sufficient memory to store at least 48 hours of chiller logs and weekly chiller plant management reports.

Other Software Features - The CPM must be capable of interfacing to a smart modem, be capable of auto-answer, and auto-dial for remote access, and shall have voice communication capabilities on-board the unit.
Graphing - The CPM must be capable of graphing the relationship of 3 inputs. This capability must be provided and demonstrated at start-up and at acceptance of the system.

Translation of Information - The CPM must be capable of including the software necessary to perform the functions of the translator described in this specification.

1.10 SEQUENCE OF OPERATION:

The CPM System will be programmed for specific sequences of operation to provide chiller plant operating efficiency by the use of automatic equipment operation, equipment protection, translation of data, and alarms. The chiller manufacturer will provide appropriate control application for customer chilled water plant and must include the following:

Adaptive Start/Stop - The CPM will minimize equipment energy use and automatically adjust chiller-pump-tower start/stop schedule(s) by zone space temperature, chilled water temperature, and historical cooling load inertia/reaction time. Chilled water pumps and chillers will be controlled separately for optimum start time and stop time. The CPM will determine if water temperature can be reduced from a level reached during idle times before starting chiller compressor. The CPM will determine if water temperature is suitable for shutdown of chiller compressor in advance of actual unoccupancy time. In no case will a single contactor be allowed to shut everything down simultaneously.

Chiller Sequencing/Selection - Lead/Lag chiller selection will be determined and can be rearranged upon customer selection. The CPM will automatically forecast cooling load requirement/trend and automatically select optimum equipment combination based on historical energy efficiency, load requirements, chiller-pump-condenser fan kW, and chiller-ready-to-run. The customer may alternatively select optimize/equal chiller run time. Chilled water valve(s) will be opened/closed based on chiller selection. The CPM shall be capable of controlling any chiller configuration. Owner shall be able to start chillers at one location or shall be able to select automatic start. Any chiller commanded to start but not doing so will be a designated alarm. Operator will be alerted to start the next most optimum chiller by chiller number location.

Optimum Chiller Load Distribution - CPM will automatically load individual chillers based on energy efficiency and optimum equipment combination. The CPM will also reset leaving chilled water temperatures on individual chiller(s) to optimize chiller load distribution while maintaining chilled water supply/return set point mode. Any parallel chiller that is in circulation but does not have water circulating, the evaporator will be in alarm.

Chilled Water Reset - The chiller(s) leaving chilled water will be automatically reset/adjusted based on one of the following (customer selectable) methods: **(1)** constant chilled water supply temperature for individual chiller or common supply; **(2)** constant return water temperature control; and, **(3)** chilled water reset based on outdoor temperature or outdoor humidity. Minimum and maximum reset limits are customer defined.

Low Load Control - An individual chiller will not be allowed to operate below a selectable operating point (i.e. 30% load) unless only one chiller is required for the cooling load. For cooling load below 25%, the CPM will select to cycle the chiller to maximize energy efficiency or select continuous operation based on cooling load inertia/reaction time and historical data.

Auto Start after Power Failure - In the event of a power failure, all equipment will remain off for a select period. One chiller and its associated pump will be sequentially started.

Auto Start of Standby Chiller - If a chiller or its auxiliary equipment fails to start or shuts down on safety failure, a standby chiller and its associated auxiliaries will be started.
Failure Alarms - The CPM shall recognize and enunciate chiller, pump, and fan failure by means of positive proof feedback and/or safety failure circuit. An alarm message will be displayed and beeper/horn sounded.
Pull-Down Demand Limiting - Upon start-up, the chiller is gradually loaded to a selectable kW limit for a selectable period of time prior to allowing full loading.
Pump Sequencing and Control - Pumps are started prior to chiller start-up and are sequenced based on chiller operation and cooling load requirement. Pump shut-down is based on same.

1.11 ALARMS AND MESSAGES:
The CPM System must be capable of displaying chiller plant alarms and messages. Minimum requirements include chiller failure alarms, pump failure alarms, condenser fan failure alarms, high/low temperature alarms, high/low alarms for all inputs, high/low alarms for all calculated variables (i.e. chiller efficiency), and CPM System diagnostics.

1.12 REPORTS AND CHILLER LOGS:
The system must be capable of accumulating and displaying chiller plant data, historical chiller logs, and reports. Minimum report requirements include chiller historical kWh use, heating/cooling degree-days, chiller run times, lead/lag selection, historical cooling load, BTUH/Ton-hrs, number of chiller failures, most recent chiller alarm, cooling tower run times, pump run times, free cooling run times, and total chiller plant (est.) power use. Minimum chiller log requirements include all chiller plant operating temperatures, pressures, chiller kW, pump, and chiller operating status, and total system (est.) energy use. All logs must be available for a previous 48 hours, in 2- hour increments.

1.13 BMS COMPATIBILITY:
The CPM must be capable of interface with a third party Building Management System (BMS) through Translator or communication link. The chiller manufacturer will provide interface instructions prior to bid so that all work by others can be identified.

1.14 PC COMPATIBILITY:
The CPM must be capable of ASCII communication to a PC through an RS-232 direct connection or telephone line. The chiller supplier must submit interface instructions and a list of PC software (proprietary or third party) capable of interface of chiller, communication, display of chiller data, reports, and alarms.

1.15 WIRING:
Wiring - The HVAC Vendor shall provide all labor, material, and install all control wiring for all sensors, control devices, equipment interfaces, and electrical power to

the CPM System. All wiring will be in accord with local and national Electrical Codes which also must be properly labeled. All wiring must be installed in EMT conduit.

1.16 PROJECT DRAWING AND DOCUMENTATION:

Project drawings must be submitted after installation and completion of the CPM System. The chiller manufacturer will provide three (3) copies of the following:
As-built wiring diagrams Installed Bill of Material Sequence of Operation
CPM System Operation's Manual

1.17 CUSTOMER TRAINING:

The chiller manufacturer will provide one (1) day of on-site operator instruction to designated customer personnel. Training will include routine operation, use of optimize

chiller plant operation, controller maintenance, and use of chiller energy management features. The CPM supplier must also offer, at the Owner's expense, a three (3) day factory training course.

1.18 SYSTEM WARRANTY

After project completion, the chiller manufacturer will provide one (1) year (or as specified under GENERAL CONDITIONS OF CONTRACT) of CPM service with total responsibility for warranty including hardware, sensors, wiring, labor, and software. The chiller manufacturer will provide a minimum of two (2) routine inspections by a qualified Service Technician who will inspect, adjust, and verify proper CPM System operation. The chiller manufacturer will provide software support, including a back-up copy of software programming and will provide minor software changes as deemed necessary by the chiller manufacturer to assure proper system operation.

1.19 SYSTEM FUTURE:

The CPM System shall be expandable into a Building Management System. Although not a requirement of this section of the specification, supplier must demonstrate that the system is fully expandable from the central plant up to a building wide system using standard components manufactured by the chiller supplier. The components are to be fully distributive and totally stand-alone modules as previously described.

CLAUSE 2.0 BUILDING MANAGEMENT / AUTOMATION SYSTEM

1) SCOPE

The Scope of this clause comprises the design, supply, installation, testing and commissioning of pre-programmed distributed digital type Building Management system (BMS) with Operator station and Direct Digital Controller (DDC) conforming to these Specifications and in accordance with the requirement of Schedule of Quantities. **At the time of Submission of Tender the contractor/contractor has to submit the detailed I/O Summary along with the Schematic.**

The scope includes hardware and software, signal & communication cabling etc., conforming to the features detailed in this specification and in accordance with the requirement of the I/O list. “Building Management System” means the portion of the control system concerned with the HVAC system. The BMS system installed shall be hierarchical in structure. The different levels shall be capable of working either independently or in conjunction with one another.

2) IBMS COMPONENTS

An Integrated Building Management system comprises of a management system for Monitoring and control of HVAC system for the following;

- Controlling & Monitoring of Secondary Pumps.
- Controlling & Monitoring of AHUs, VAV Boxes.
- Controlling & Monitoring Pressure Independent Flow Control Valves.
- Prevention & Maintenance schedule.
- Energy Meter recording and Billing system.
- Filter status monitoring.
- Integration of BMS system available in the ACMV package through ODBC/OPC.

The design of the Integrated System shall have integration of the smallest sensor to the operator workstations (Computers) with all functions of the entire building services available at the control stations. Integration shall mean all the parts of system are connected together through software and shall share all the information. The integration of all systems shall be achieved through software programs, electronic components, hardware packaging and communication network through Local Area Network through IP.

2.1) <u>IBMS has following parts</u>

(a) Automation stations
(b) Field control devices/components
(c) Field communication network
(d) Main server
(e) LAN Network
(f) DDC controllers
(g) Process Data Manager which process data from the field through required interface.
(h) Central Monitoring Station (CMS) with sub systems, which provides graphical user interface

- The Automation stations are autonomous, networked units. Multiple networks may be required to be installed.
- Each network is an island and forms a sub-network. The sub-network shall function independently to ensure against total system failure and isolation / speedy servicing in the eventuality of a bus fault. However the end controller shall be provided with IP based in respective locations.
- All such islands of network shall be interconnected at the MAIN MONITORING/CONTROL STATION or gateway level. Thus multiple islands can interact to form a common network link to the Operator Stations over LAN Network.
- DDC controllers connected on the sub-networks shall have full peer-to-peer capability.
- Local storage at DDCs of minimum 1000KB shall be provided.
- Hot standby feature shall be provided for smooth interruption-free changeover in the event of a Main station failure.
- Hot standby /parallel redundant feature shall retain communication with the field network and all data shall be available at the standby unit continuously to integrate to Operator station.
- The Main Operator station shall function as a viewing and controlling workstation operated through any standard Graphical User Interface software or web browser.
- The main Operator station is not required to pool data from the field or be communicated by any interfaces to the field but shall access data from sub-system.
- It must be possible to access and control the operation of one system from the other system in case of necessity.
- The system shall allow for operation scheduling, sequencing of various systems, maintenance shutdowns etc.
- The system shall record alarms, events and other measurements and shall create a historical database.

2.2) <u>IBMS shall provide following functions:</u>

- Supervise the operation of the facilities listed above
- Facilitate quicker response time in respect to complaints
- Better coordination of monitoring and control
- Database for recording system history, information and management pertaining to preventive maintenance
- Facilitate to control from a remote location using internet/intranet.
- Optimum energy utilization.
- Shall provide open system architecture on which several other third parties system can be connected through required software drivers.
- Coordinated emergency procedures.
- Advanced smart alarm management system (mobile, pager, and fax).
- Maximum demand controller recording.
- Metering bus interfaces & Power consumption details

3) FUNCTION OF INTEGRATED BUILDING MANAGEMENT SYSTEM

The scope includes Supply, Installation, Testing and Commissioning of operator work stations (PC) including hardware and software conforming to the specification, drawings and schedule of quantities.

The IBMS and BMS shall accompany all the integration features and work seamlessly. The integration shall cover various subsystems provided by other contractors confirming to the specification, drawings and schedule of quantities.

4) HARDWARE

The Main Operator work station shall comprise of windows based function units necessary to acquire data directly or through a gateway / router, store, visualize and communicate with other, providing high-level operator interface with the system. It shall provide for GUI (Graphical user interface.) with the system. The operator station shall support consistent archiving of alarms, offline trend data and data backup.

5) THE OPERATOR STATION COMPRISING OF THE FOLLOWING

PC comprising Intel i7 processor, Intel mother board, 16 GB DDR5 RAM @ 1 Ghz, 1 TB HDD , Keyboard, Optical mouse, ATX Cabinet with SMPS Prime Source, DVD Writer, Speaker with MS windows 11 operating system. The system should be supplied with 40" LED Color Monitor.

- It shall have minimum 3 serial and 1 parallel port operation facility
- The CPU shall have a LAN card with 2 USB ports
- One set of speakers with necessary interconnection wires.
- The system shall be provided with pre-loaded antivirus software.

6) SERVER

Up graded version with Intel Xeon 3.0 GHz or 3.2 GHz processors(dual processor capability) with 1-MB level 2 cache standard, Processors include support for Hyper-Threading and Extended Memory 64 Technology, Intel® E7520 chipset, 800-MHz Front Side Bus, Integrated Dual Channel Ultra 320 SCSI Adapter, 8 GB DDR4 RAM, Six expansion slots, Three USB ports, Internal storage capacity of up to 2 TB, with hot plugable HDD's, 12/24 DAT Tape drive, LED 32” Color monitor, optical Mouse, 106 keys key board, 725W Hot-Plug Power Supply, 725W Hot-Pluggable Redundant Power Supply & with GSM modem. MS Windows 10 operating system with IIS & MS office. The Server should be loaded with antivirus software.

7) PRINTER

The Laser monochrome printer shall be provided with 12ppm or higher (paper per minute) and a Colour inkjet printer with 12ppm or higher and with suitable resolution.

One colour printer shall be capable of printing visitor data along with photo ID. A 4 size - Colour / Block = 31/ 32 ppm or higher.

8) SOFTWARE

The system shall be completely modular in structure and freely expandable at any stage. Each level of the system shall operate independently of the next level.

- The Management Level:

- The head-end of management shall be multiple of sub system.
- The Main operator station includes process visualization, data analysis.
- The system shall be open for vertical and horizontal integration.

- Network:

  - The system configuration shall facilitate the current network to be expanded in future at locations designated by the user.
  - Central management of user-specific information such as passwords and protected access to data and programs shall be made easy.
  - The management system shall support software updates and changes in the project data.

- Automation level:

  - The logic written on the DDC shall determine the level at which the actual processing takes place.
  - The processes are carried out at DDC controllers for autonomous control (all control functions shall be independent of the network/other DDCs).

- DDC programming SOFTWARE

  - The software shall be a graphically programming tool. It enables the user to;
    - Make a function diagram to parameters.
    - commission all the automation station
    - Change the parameters etc when the system is in operation.
  - The software shall be windows based.
  - The software shall be modular, structured and shall be based on Window 11 standard 64-bit technology

- Process visualization software Features:-

  Each system shall have the following software incorporated with

  - Open system
  - Web technology
  - Provision shall be made for supporting the web Clients
  - Scalable system
  - System redundancy
  - Smart user/maintenance management
  - Smart alarm management (Advanced alarm module: notification via SMS, fax, email)
  - Web scheduler

- The Software shall be a flexible, user-friendly and user programmable package. It shall allow the operator to construct customized display screens

and programs for control, monitoring and information management and analysis.

- The System Software shall comprise the real time operating system, Communications Control, Graphical Operator Interface which includes editors and viewers with original licenses for editing and viewing.
- The editors shall include Schematic editor, trend editor, alarm editor, event editor, report editor, and web application editor.
- The Software shall provide true multitasking, concurrent execution of multiple real time programs and custom program development.
- Switching from foreground applications to background applications where the background applications are suspended shall not be permitted.
- The software program configurations will be done in English language.
- The Software shall allow the user to modify and tailor the Operator Interface software to the specific and unique requirements of the equipment installed, the programs implemented and to staffing and operational practices.
- Online modification of system configuration, program parameters, and data base shall be provided.
- The Software shall provide a hierarchical linked dynamic GUI for accessing and displaying system data, commanding and modifying equipment operation.
- The graphics shall form the main interface for all the operator actions.
- Any level of graphic penetration shall be provided with the operator assignable hierarchy. (ex: area, building, wing, floor, AHU, Valve, VAV Box, sequence of operator pages, dynamic program display, point group etc.).
- Dynamic system data points shall be assignable to each penetration level.
- Descriptors for graphics, points, alarms etc. shall be able to be modified through operator station under password control.
- Points shall be unique with respect to coloration, animation, audible rate and duration, point descriptors, operator messages, alarm archival option, alarm and warning limits, and engineering units.
- It shall be possible to make point related changes such as system /point enable/disable; run time enable/disable; analogue value reset, lockout, run time limits, and setting a fixed input or output value /status.
- Sign-off from a station shall be a manual operation.
- All sign on/Sign-off activity shall be automatically indicated on the operator station disk for subsequent display or printout.

9) GRAPHICS

- Operator access to system points shall be controlled by individual operator assigned graphic hierarchy and by privileges.
- An operator shall have access to only those graphics and points assigned to him.
- The hierarchy shall permit operator to access initially assigned graphic and to all graphics linked to and below the initial graphic.
- The operator shall not have access to graphics in another hierarchical graphic “tree”.
- Each operator shall have combination of user assigned operating privileges of alarm acknowledgement, point commanding, data modification, and operating system access schedule and system configuration changes.

- The graphics shall provide the operator dynamic screen displays of real time data with full color animated displays of equipment status, site layouts/building plans and other system configurations.
- The user shall be able to develop or modify graphic displays and assign and position any array of points within each group “Online”.
- Creation of graphics and assigning of points to the graphics shall not interfere with point archiving and alarms.
- Graphics shall be created via mouse and keyboard selection of graphic library stored symbols and system profiles.
- The Software shall provide the capability to create custom symbols, system profiles, floor plans, buildings etc and to store them in the graphic library.
- It shall be possible to import third party developed files of the type *.bmp, *.jpg etc. These imported files shall be displayed as regular graphics with dynamic displays programmed on them.
- It shall be possible for the operator to change/penetration from one graphic to another by a simple mouse click on the graphic.
- It shall be possible to select further penetration / change via a mouse click on an area, building, floor, fan etc. The defined linked graphic below that selection shall then be displayed.
- Dynamic data shall be assignable to any and all graphics.
- It shall be possible to display all data on a graphic regardless of physical hardware address, communication channel or point type (temperature, humidity, fire etc.)
- Data points may be assignable to multiple graphics where necessary.
- Graphics shall contain calculated or pseudo points. Each physical point and point assigned to a graphic shall be assigned an English descriptor for use in reports.
- Points (Physical and pseudo) shall be displayed on the Graphic with dynamic data provided by the system with appropriate text descriptors, status or value, and engineering unit.
- In order to view graphics in greater detail, a zoom/pan display feature shall be provided.

10) COLORATION

- Coloration shall be used to indicate status and alarm condition
- Coloration schemes shall be variable for each class of points as chosen by the user.
- It shall be possible for the user to create and apply custom colors to depict different equipment status and conditions.

11) ANIMATION

- Dynamic animation shall be used to represent data (e.g., fan rotation, damper position, fluid flow, tank levels, etc.)
- It shall be possible to customize animation to enable effective depiction of real time data on the screen.
- The animation shall be applicable to both analog and digital points.

12) SIMULATION OF POINTS

- It shall be possible for the authorized operator to simulate a point condition from the operator station for testing the logic/control functions without physically having the input devices connected.
- It shall be possible to simulate all types of point's i.e. analog as well as digital irrespective of the nature of point hardware.

13) HELP

- An on-line project specific, context-sensitive "help" utility shall be provided to facilitate operator training and understanding.
- The document shall contain text and graphics to clarify system operation.
- Help shall be available for every menu item and dialog box.
- The system operation on a single mouse click shall call up the help document pertaining to the dialog box that is currently on.

14) MISCELLANEOUS

- Messaging and Alarm routing facility shall be provided on the operator station for e-mail, mobile, pager, fax etc., (Alarms like "MCP FAULT" and message like Change Break Glass Unit).
- The operator shall be able (against the password control) to command a point without having to place the system in manual mode.
- For a digital command point for example a 2 position damper actuator, the actuator shall show its current state (e.g.: say "Closed") and operator shall be able to select "Open" via a mouse click. A keyboard option shall also be available.
- For an analog command point, such as cooling coil valve, the dialog box shall provide facility to change the value as under.
    - By clicking the cursor on the set point value and entering a new value through the keyboard.
    - By driving the value up or down via the up, down arrows or slider feature

15) SOFTWARE APPLICATION

The main software applications shall comprise

Plant/Building Viewer	:	Graphics based operation of the Plant/Building
Trend Viewer	:	Logging and display of measured value
Alarm Viewer	:	Display of alarm messages
Alarm Router	:	Automatic routing of alarms

Event Summary logging of alarms, system events and user Activities.

16) PLANT/BUILDING VIEWER

The plant/building viewer shall support the following features;

- Hierarchically linked animated high-resolution bit-map color graphics.
- Choice of 2D and 3D symbols with animation based on status.

- Direct access to set points, parameters, operating modes, alarms, time programs, on-line and off-line trend features.
- Dynamic multi-tasking with all active pages.
- Monitoring and operation of various equipment in the facility at several levels.
- Navigation to all other management station software applications.
- User definable page size.
- Jump tags for jumps on the same level or between levels.
- Capable of graphics to be printed in colour or monochrome.
- All graphic file formats supported by Windows can be imported (e.g. jpg, bmp etc.,).

17) TREND VIEWER

The trend viewer shall have the following features

- On-line or off –line real time data.
- Simultaneous display of up to ten signals per window
- Absolute or relative time intervals.
- Zoom, scroll and cursor features for faster data analysis.
- Flexible, easy to use scaling feature with charts displayed in 2D or 3D.
- Management station display and archiving of on-line and off line trend data
- Printouts of trend data.

18) ALARMS HANDLING & ALARM VIEWER

As a minimum, the system shall support the following features;

- Operation and manipulation of alarms (based on user privileges).
- Alarm message printing.
- Alarms printed independently of the central station (direct connection at automation level).
- Automatic pop-up windows for immediate display of operation of alarms.
- Audible or multimedia alarm indication.
- Continuous overview of all active alarms from site (updated automatically, displayed in order of priority, option of personalized view).
- Option of displaying detailed information.
- Direct access to associated plant/building graphics.
- Comprehensive filter and search criteria (time, date, priority, discipline, alarm status etc.,).
- Color-coding based on alarm priority/alarm status.
- Alarms for out of limit values (high, low), change of status, run time limits exceeded etc.
- Option of repeating unacknowledged alarms at regular intervals.
- Facility to save user-defined criteria.
- User-specific configuration of the alarm view including on-line configuration.

Alarm management services shall also report the system alarms such as

a) DDC failure
b) Network failure

c) Communication error with DDC/PLC d) Disk full

19) ALARM ROUTER

In order to monitor alarms round the clock, alarm routing is an important feature of the IBMS. The IBMS shall have the following features;

- Routing of alarms to alarm printer, fax pager or mobile phone.
- Time schedule for each message recipient.
- Alarm routing based on priority
- Alarm routing based on discipline (Security etc.,).
- Alarms routing to person responsible at site.
- Alarm routing based on text.
- Alarm routing to person(s) responsible for specific equipment or systems.
- Option of manual transmission of messages from the management system.

20) EVENT SUMMARY

The Event Summary enables the operator to see the active alarms and events and to acknowledge the alarms. The features are as follows.

- It displays the active alarms and events according to the events summary profile definitions that have been set by the system integrator.
- The system integration enables the operator to change some of the settings of the Event summary.
- The Event summary profiles file should contain the filter (zones, severity, stations), security/feature options, default display options, default colour and default sort order.
- Event summary displays filtered alarms and events by using filter.
- Event summary enables to assign colours to the alarms and events displayed in the browser.

21) TIME SCHEDULING

The time scheduler shall have the following features

- Weekly/Monthly time programs.
- Exception programs (local, building wise or system wise).
- Direct display of time programs within Plant/ Building viewer graphics.
- Direct entry of various operating modes.
- Easy creation, modification and deletion of all time programs.
- Scroll features for fast access to specific weeks or days
- Printed reports in various display forms.

22) WEB SCHEDULER

The web scheduler shall function over a standard web browser and shall be accessible through a standard Internet/Intranet connection and enables remote development of all scheduling programs.

Using the browser the user can do the following.

- Define/modify tasks.
- Define as many states as required for each task.
- Define as many actions required for each task.
- Schedule a timetable for each task.
- Create weekly timetable templates and to use these templates later for tasks.
- Activity blocking both partially and fully for special days (some holidays, religious days).

23) EXCHANGE OF DATA THROUGH STANDARD INTERFACES

- The system shall be an open system using an OPC, (OLE for process control (Object linking embedding)) which is a standard communication protocol to exchange data.
- The system shall support the use of standard interfaces and drivers that make it easy to integrate with third party software.
- This integration shall be directly at the management station level or to make common use of data from the system, e.g. via ODBC (Open Database Connectivity).
- DDE (Dynamic Data Exchange) shall enable current data to be loaded continuously into a spreadsheet program such as MS Excel.
- The system shall be capable of integrating with third party system using Modbus RTU/ BACNET/LON works/Ethernet IP protocols.

24) REPORTS

- Reports shall provide the user with the latest information from the system at specific times or when specific events occur.
- The following features shall be supported;

    - Reports routed on basis of time and /or priority.
    - Manual or automatic triggering.
    - User-definable or standard reports.

25) ACCESS PROTECTION

- The management station shall grant access to the system only to authorized users.
- The system administrator shall adapt to an environment to match the individual requirements of each user.
- The access protection facility shall define sites and equipment to which a given user has access and the software functions available to the user within the site.
- The system shall support the following features

    a) Access to control and develop functions is protected with User name/ password.

    b) Individual access privileges covering access to sites, subsystems, and program functions down to individual objects in Plant/ Building Viewer.

c) Encrypted Passwords.
d) Association of users to groups.
e) Association of objects to groups.

5. Every single group shall have the rights to

a Lock a station
b Shut down a station
c Log off
d Change the password

26) TOTALIZATION

1. For every digital point, the system shall be able to calculate:

    a) Cumulative on-time
    b) Cumulative off-time

2. For every point, analog and digital, the system shall be able to calculate:
    a) Cumulative alarm time.
    b) Cumulative time overridden by operator
    c) Cumulative off-line time.

3. Time tantalization shall have a resolution of one minute or less and shall be displayed in hours and minutes

27) SYSTEM DESIGN

- The DDC controller shall be a decentralized module with autonomous intelligence
- It shall be able to process, store and handle a large volume of data and meet all the demands placed on it.
- It should not need to be supported / located centrally.
- The System shall co-ordinate the flow of data in both directions.
- It shall be responsible for the communication upwards with the management station, on the same level with other system controllers, and downwards with the field devices.

28) DATA EXCHANGE

- The interface transmits and receives data both via the DDC bus and trunk bus via System controller.
- The tasks of the interface shall include:
    a) Processing the installed DDC data points.
    b) Converting local system controller addresses (DDC) into physical DDC module addresses.

c) Monitoring network and DDC bus communication.
d) Optimizing communication between the interface and the system controller.
e) Synchronizing date, time adjustments in the interface and the DDC modules.

29) THE DDC CONTROLLERS

- The direct digital controller shall be designed with functions distributed both physically and functionally over the field controllers.
- The DDC shall be truly autonomous with peer-to-peer communication. However the end controller shall be provided with IP.
- The DDC shall have the following minimum features:

a) 64-bit processor
b) Inbuilt real time clock with a battery backup for a minimum of 3 years.
c) i) Inbuilt memory for viewing any historic data base at least for 1000 KB events of various signals in each controller.
ii) Stipulated parameters such as temperature, RH, pressure etc shall be stored in each controller.
iii) These parameters shall be available for viewing/uploading in case central system is switched off or communication network is under maintenance.
d) Provision shall be available for connecting laptops or PC directly to DDC for local evaluation.

- The autonomous controller for each unit shall be with EPROM and EEPROM.
- It shall also have Flash ROM chip of required capacity with function blocks for performing required closed loop and open loop (interlocks) functions at various locations.
- The controller shall be housed in proper lockable enclosure, providing for required data acquisition, processing capability etc as required.
- The controllers shall be completely wired.
- The controllers shall have all interface relays required for interfacing with external system like MCC etc.
- Autonomous DDC Controllers shall be able to access any data directly with any other DDC Controller or combination of controllers on the network without depending on the central processing/monitoring station.
- These controllers shall also work without dependence on Main operating station.
- DDC controllers shall be provided with I/O points as per schedule.
- Each DDC controller's location shall have 10% spare capacity for future expansion.
- The expansion /addition of I/Os shall be possible
- The DDC controllers shall also house the associated terminal blocks, power supply, relays (with change over contacts),etc.

- They shall also have self diagnostic (testing) capabilities to monitor healthiness of the controller.

30) CONTROL STATION FUNCTIONS

The following user program / functions must be processed/ carried out by the Control Station

i. Operating functions
- Via graphic management schematics with dynamic display of actual status information.
- Manual control of parameters and status variables of the electrical and mechanical equipment.
- Manual switch of programs which are not part of progress routines.

ii. Monitoring functions
- automatic monitoring of connected equipment
- automatic monitoring of the system (idle or operation)

iii. Data Visualization functions
- Individual processing of operating data for Building Management.
- comfort chart data for temperature / humidity using psychometric chart in standardized form for;
  - trend reports
  - consumer statistics
  - fault statistics
  - maintenance management

iv. Display functions
- For the representation and display of operating data and management information in alphanumeric and graphic form.

v. Management functions
- for optimization of energy consumption.
- for rational use of personnel

Access control functions
- Different operating levels for all information and all data by way of code word or user key.

vi. Commissioning functions
- for system specific software of the field stations and the management system
- Downloading the system specific software to the DDC units.
- Testing of the software in connection with electrical and mechanical equipment.
- Automatic and periodic storage of all system data.

vii. Test functions

- automatic and continuously running test functions for system tests (hardware and operating software) and management system configuration (communication)
- test tools for individual hardware and software components which can be activated manually.
- Self test functions for individual system components which can be activated manually.

31) CABLE AND CONDUITS

- The works shall be done as per standards.
- The work shall be supervised by qualified Engineer.
- The layout work shall begin only after getting the approval of Engineer-in-charge or his duly authorized representative at site of work.
- The following wiring shall be done in separate conduits;
    a. Power wiring
    b. Control wiring
    c. Signal wiring
- The MS conduit shall be of IS marked, stove enamelled. The conduits shall be delivered to site in original bundles and each length shall bear the label of the manufacturer. The materials brought at site shall be with proper challan with quantity mentioned on it.
- The makes of material have been indicated in the list of approved makes. No other make will be acceptable. The material to be used in the work shall be got approved from the Engineer-in- charge before its use at site. The Engineer-in-charge shall reserve the right to instruct the contractor to remove the material which, in his opinion ,is not as per specifications
- All hardware material such as nuts/bolts /screws/washers etc. to be used in the work shall be zinc/cadmium galvanized iron.
- The outer surface of conduits including all bends, unions, tees, junction boxes etc. forming part of the conduit system, shall be adequately protected against rust. The conduits are to be painted with 2 coats of red oxide paint before they are fixed. All bare threaded portions shall be treated with anticorrosive preservative (or) approved plastic compound.
- At the time of laying conduit pipe in the slab in recess, the contractor will keep fish wires of 18 SWG GI wire throughout conduit pipe and will have to take special care so that the conduits do not pass through air-conditioning ducts , grills, beams etc. If any, such necessity is foreseen special written permission of the Engineer-in-charge will be obtained before such work is carried out. In case of failure, the contractor will not be paid on this account and the work has to be redone by the contractor as per direction of Engineer-in-charge.
- The conduits are to be concealed in the walls before the walls are plastered and work is to be done in coordination with building work. Any damage thus done will have to be made good by the contractor at his own risk and cost. The conduit pipe should mechanically and electrically continuous.
- Wherever it is not possible to provide rigid conduits, flexible metallic pipe shall be provided for running the wires. However, such arrangement has to be kept to the barest minimum and to be done only with the prior approval of Engineer-in-charge.

- Different colour painting shall be done for different wiring as per the Standards.

32) CONDUITS AND WIRING

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy himself about the sufficiency of number and sizes of conduits, sizes and location of conduits and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of Architect/Engineers. Any modifications suggested by the Contractor shall be got approved by the Architect /Engineers before the actual laying of conduits is commenced.

33) CONDUIT WORKS

- The work shall be done as per standards for Electrical works as amended from tine to time and Indian Electrical Rules as amended up to date.
- The lay out of the work will be given be the Engineer-in-charge or his duly authorized representative at site of work.

34) CONNECTIONS

- All jointing methods shall be subject to the approval of the Engineer-in-charge.

35) DRAWING OF CONDUCTORS

- While drawing insulated wires/cable into the conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors.
- Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square to avoid depression/cutting of conducting material.
- Strands of wires shall not be cut to accommodate & connect to the terminals. Terminals shall have sufficient cross-sectional area to take all the strands.
- No wire shall be drawn into any conduit until all work of any nature that may cause injury to wire is completed. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction.
- Where wires are connected to detectors, or panel, sufficient extra length of wires shall be provided to facilitate easy connections and maintenance.
- Only licensed supervisors/wiremen shall be employed for cabling and other connected work. Only approved make of cables shall be used. The cables shall be brought to the site in original packing.

36) MODE OF MEASUREMENT

i. Signal Cable

The cabling running between DDC controllers to the field devices shall be termed as signal cabling. This cabling along with conduits shall be payable on running meter basis.

ii. Communication Cable

The cabling running between the system integration units to the DDC controllers shall be defined as communication cable. This cable shall also be measured on per running metre basis.

37) SPECIFICATION FOR CABLES

The cable shall be manufacture/tested as per the latest IS standards.

- Signal and communication Cable: (shielded)

The signal cable shall be of the following specifications: (communication cable)

- Wire : multistrand Copper
- Size : as per SOQ
- No. of conductors : : as per SOQ
- Shielding : Overall belt foil aluminum polyester shield.
- Jacket : Chrome PVC

38) ENCLOSURES FOR CONTROLLERS AND ELECTRICAL PANELS

- All the controllers shall be housed in Lockable Vandal proof boxes which shall either be floor mounted or wall mounted. These shall be free standing, totally enclosed, dust and vermin proof and suitable for tropical climatic conditions.
- The panel shall be metal enclosed 14 SWG CRCA sheet steel cubicle with gaskets between all adjacent units and beneath all covers to render the joints dust proof. All doors and covers shall be hinged and latched and shall be folded and braced as necessary to provide a rigid support. Joints of any kind in sheet metal shall be seam welded with welding slag grounded off and welding pits wiped smooth with plumber metal.
- All panels and covers shall be properly fitted and secured with the frame and holes in the panels correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with nuts. Self-threading screws shall not be used in the construction of control panels. Knockout holes of approved size and number shall be provided in the panels in conformity with the location of incoming and outgoing conduits/cables. Clamps shall be provided to support the weight of the cables. The dimension of the boxes shall depend on the requirement with the colour decided in consultation with the Engineer in charge.

Part 2
TECHNICAL SPECIFICATIONS FOR VRV/F BASED AC SYSTEM

Chapter 1
GENERAL CONDITIONS

1) GENERAL DISCRIPTION:

1.1 SCOPE :

This scope of VRV/F type system comprises of the design, assembly, supply, packing for transport to site, loading and unloading, handling of equipment at site, erection testing and commissioning into service, carrying out all the acceptance tests and handing over the VRV/F HVAC system to Department as per schedule of Quantities, tender drawings and conforming to the Technical specifications and general conditions.

The HVAC contractor shall design / calculate the equipment capacities based upon design parameters specified for the system design & verify all the capacities, quantities, sizes of refrigerant pipe, fitting & cables, control cable, pipe insulation, indoor units, outdoor units etc. before placing the order to avoid any shortfall or surplus. The tenderer shall include all necessary civil work and MS frame work for installation of outdoor and indoor units of VRV/F air-condition system for proper functioning.

1.2 **EXPERIENCE, SERVICE SET UP, MATERIALS AND WORKMANSHIP**:

All materials used shall conform to the requirements of materials specified in this specification. Where material requirements are not specified they shall conform to the applicable standards and codes approved by the Department. All materials shall be new free from defects and first class in all respects. Parts shall be free from flaws and objectionable imperfections and shall be machined true in a workman like manner. No deviations from the specified materials are permissible. Wherever materials are not specifically called out, they shall be properly selected by the contractor to the best standards for the particular application and with the prior approval of the Department.
Where the drawings and specification are conflict, the most stringent shall be followed. The instruction of EIC shall be final & binding. The Tenderer shall point out all deviations from the drawings and specifications in their offer and shall specifically confirm the works not included. Once the Order is placed for the entire system with the tendered schedule of quantities no extra shall be payable on any account thereafter.

The contractors proposal must include everything required to make a complete working of the system with all required materials whether specifically specified or not and their transportation etc, including labour for necessary to complete the installation. The contractors shall obtain the statutory approval if required everything shall be considered to complete the system and ready for Owner's use. It shall be the responsibility of tenderer to check the suitability & site constrains for installing the system at site.

Any apparatus, appliance material and labour which may be necessary to complete the work in accordance with the intent or purpose of these specifications and as instructed by EIC, the execution of the project shall be considered by the contractor without an extra cost irrespective of Technical specifications or on the drawings.
The work shall be done in conformity to the specifications, accompanying drawings and with the requirement of the general, architectural and structural plans & other regulatory & statutory bodies including CFO, if required.

1.3 STANDARDS & CODES:

The design, manufacture and performance of equipment shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the requirement of the latest editions of applicable IS/ B.S Standards and CFO clearances if required. The contractor shall refer the relevant sections of this specification for equipment standards and codes. Nothing in this specification shall be construed to relieve the contractor of his responsibility.

List of Standards for Refrigeration, Air Conditioning & Ventilation Systems

		A) Glossary of terms symbols & terminology
1	IS 3615	Glossary of terms used in refrigeration and air-conditioning.
2	IS 4831	Recommendation on units and symbols for refrigeration
3	IS 10609	Refrigerants – Number designation
		B) Safety Standards
1	IS : 659	Safety code for air-conditioning (revised)
2	IS : 660	Safety code for mechanical refrigeration (revised)
		C) Standards relating to method of testing & code of Practice
1	IS : 5111	Code of practice and measurement procedures for testing refrigeration compressors
2	IS : 7613	Method of testing panel type air filters for air-conditioning and ventilation purposes
3	BS : 4856	Method for testing & rating fan coil units.
4	IS : 441	Standard for equipment testing, rating of room fan coil air conditioners.
5	IS : 5456	Code of practice for testing of positive displacement type air compressor and exhausters.
		D) Product Standards
1	IS : 655	Metal air ducts (revised)
2	IS : 10617 (Part I to III)	Harmatic compressors
3	IS : 10594	Thermostat expansion valves
4	IS : 11329	Finned type heat exchangers for room air – conditioners
5	ASA-B : 31.5	Code for refrigerant piping

	BS : 5720	Code of practice for mechanical ventilation and air-conditioning in building.
	ARI : 410	Standard for forced circulating air cooling and air heating coils.
		(E) Sheet Metal work
	IS : 277	Galvanized steel sheets
	IS : 665	Metal air ducts (revised)
	IS : 702	Hot bitmen
	IS : 8183	Thermal conductivity
	IS : 3183	Mineral Wool
	IS : 1663	Method for tensile testing of steel sheet & Strip of thickness 0.5mm to 3mm.
	IS : 2629	Recommended practice for hot-dip galvanizing of iron & steel
		(F) Electrical system
	IS : 325	Three phase induction motors
	IS : 1231	Dimensions of three phase foot mounted motors.
	IS : 4691	Degree of protection provided by enclosure for rotating electrical machinery
	IS 3202	Code of practice for climate proofing of electrical equipment
	IS : 4728	Terminal marking and direction of rotating for rotating electrical machinery.
	IS : 4029	Guide for testing three phase induction motors.
	IS : 4729	Measurement & evaluation of vibration of rotating electrical machines.
	IS : 4889	Method of determination of efficiency of rotating machines
	IS : 2253	Types of construction and mounting of induction motors
	IS : 2223	Dimension flange mounted induction motors
	IS : 2968	Dimension of slide rails for electric motors.
	IS : 4722	Rotating electrical machines
	IS : 7816	Guide for testing IR of rotating machines
		(G) Power & control cables
	IS : 1554	PVC insulated electric cables (Heavy Duty)
	IS : 694 (I)	PVC insulated cable with copper conductor
	IS : 8130	Conductors for insulated electric cables
	IS : 5831	PVC insulted and sheathed electric cables
	IS : 3961	Recommended current rating of cables
	IS : 1554	G.I. armouring
	IS : 732	Code of practice for electrical wiring installation upto 650 V
	IS : 1646	Code of practice for fire safety of bldg. (General) Electrical installations
	IS : 5908	Method of measurement of electrical installation in building.
	IS : 3043	Code of practice for earthing
	IS : 5216	Guide for safety procedures and practice in electrical works.
	IS : 900	Code of practice for installation & maintenance of induction motors.
	IS : 3914	Code of practice for selection of A.C. induction motor starters . Voltage not exceeding 1000 Volts.
	Regulation & Rules	Indian electricity rules factory act and regulation other statutory local, state & municipal regulations, National electric code -1980

1.4 TENDER DRAWINGS:

The Tender Drawings are only conceptual have been prepared by the Department showing the locations, system equipment layout & schematic diagram for VRV/F HVAC system works.

The equipment layout, duct layout & pipe work as shown in the drawings represent as feasible scheme based on space available. The contractor may rearrange the space allocated subject to the approval by the Engineer-in-charge.

These drawings are not meant as working drawings. The contractor shall prepare detailed working drawings and got them approved by the Department (DCSEM) before starting the work. After completion of work, the contractor shall have to submit "As built drawings" of minimum six hard copies each along with the soft copies which will be kept in the department.

The scope of VRV/F air-conditioning shall be with outdoor and indoor units as specified in BOQ .The specified design parameters are only tentative in nature. However, based on the location of installation, if any higher capacity outdoor/indoor units are required, the design analysis shall be submitted by the agency for necessary approval.

1.5 BRIEF SCOPE OF WORK:

The VRV/F air conditioning system shall mainly consist of following equipments & accessories.

7.1 SITC of VRV/F system operating on R-410A or any other eco friendly refrigerant. The system shall consists of outdoor units inbuilt fixed and all variable speed refrigerant compressors, foundations, central remote controller with PC including required hardware & software for entire system along with the communication, power & control cables etc.

7.2 SITC of Cassette, High wall & fresh air VRV/F indoor units with floor wise group controller & remote controllers etc. as per drawing.

7.3 Refrigerant piping, valves, distributor headers / Y joints / refnet joints etc. with nitrile rubber thermal insulations with weather protection coverings etc.

7.4 Treated fresh air units as per drawing.

7.5 Flexible fresh air ducting along with the air dampers & supply air grills as per drawing.

7.6 GSS Air ducting, dampers, canvas connections & supply air grills wherever required.

7.7 The required accessories to put the system for satisfactory completion.

7.8 G.I. Insulated Condensate drain piping.

7.9 All refrigerant pipes at a terrace levels and in service shafts shall be protected with a GI sheet covering.

7.10 Walkable platform with MS angle frame supports shall be provided at terrace refrigerant pipes.

7.11 Electrical power distribution panel in weather proof enclosure at terrace level for VRV/F system.

1.8 THE FOLLOWING WORKS NOT INCLUDED IN THE SCOPE OF HVAC BIDDER. THE SAME CONTINGENT WORKS SHALL BE TAKEN INTO THE RESPECTIVE CIVIL, PH & ELECTRICAL WORKS.

A) CIVIL WORKS:

a. All windows of air conditioned areas shall be air tight and the window glasses shall be provided with sun film / Venetian blinds.
b. Air tight doors shall be provided in the air conditioned areas.
c. Provision of air tight false ceiling & vertical masking with trap door opening for installation maintenance cassette units, fresh air units and duct dampers as per drawing.
d. Thermal insulation shall be provided for the sunroof areas of air-conditioned areas.
e. Wooden frames shall be provided in the wall for fresh air ducts as per drawing.
f. Terrace floor shall be slopped towards the drain to avoid the water clogging near VRV/F outdoor units & electrical power panels.
g. Provision of HDPVC pipe sleeves in wall for refrigerant pipes wherever passing through the walls as per drawing.
h. Provision of wooden / marine plywood paneling on walls for refrigerant pipes and condensate pipes of a high wall unit.
i. False ceiling as per the HVAC drawing.
j. Fix glass ventilator window height shall be modified to suit the false ceiling levels as per HVAC drawing.

B) ELECTRICAL:

a. Provision & termination of required 3 phase power supply along with power cable and adequate earthing in VRV/F HVAC units power panel at terrace.
b. Provision of required single phase power supply points with MCB above false ceiling level from the floor & its metal clad socket with top outlet near the cassette and high wall units at various floors as per drawing.

CHAPTER 2
VRV/F AC SYSTEM

2.1 SYSTEM DESCRIPTION:

The air cooled variable Refrigerant Volume / Flow (VRV/F) System shall consist of outdoor & indoor units working on R-410A or any other eco friendly refrigerant.

The outdoor units shall assembled in adequate metallic cabinet with foundation frame consisting of multiple inverter scroll type compressors of variable speed for all compressors, condensing units, condenser fan, interconnecting refrigerant piping, starters, power & control wiring with Micro Processor controller in IP55 to give approx. 10% to 100% variable capacity as required. The Entire Condensing units and Evaporating units should be factory assembled and tested.

The units should come with an initial charge of refrigerant R410a or equivalent of CFC free from the factory. The outdoor units shall capable to connect to the multiple type indoor units with different cooling ratings. All the indoor units shall have cordless Remote Controller as a standard accessory. The outdoor and indoor units shall be controllable with a common microprocessor based controller with required hardware, software, power & control cables etc to monitor & control their operation.

All outdoor units shall have multiple steps of capacity control to meet load fluctuations and indoor units with electronic expansion valve shall control at variable loads. The entire system shall be suitable for operation on 415V, 3 phases, 50 Hz AC electric supply.

Based on the project requirements and wherever applicable as per schedule of quantities, the intelligent Micro Processor system along with the required hardware, software's shall be interfaced with personal computer (PC) which is located at operators table at a ground floor for monitoring & operation of all outdoor & indoor VRV/F units. The tenderer shall include all power, control cables & interfacing devices as required. The monitoring & control system shall have minimum following features:

a) On / off of individual outdoor & indoor units.
b) Monitor & display the temperature of air in the room / area were served by indoor units.
c) Indication of number of indoor units and outdoor units working.
d) Setting of temperature and timings.
e) Electrical power consumed in KW by all outdoor units & load current monitoring.
f) It shall be possible to switch off any of the outdoor unit compressor on a command from corded controller and personal computer during any emergency.
g) To start / stop any indoor unit at preset times and it shall be possible to change the time settings.
h) Indoor unit air filter clogging indications.
i) Outdoor unit / compressor hours of operation.
j) Programming functions for start & stop of the system.
k) Condensate drain pump failure indication.
l) Duty cycling for switching the starting sequence of multiple outdoor units.

2.2 AMBIENT CONDITIONS:

The system shall be capable of operating within a wide range of maximum ambient temperature of 45 Deg. C. DB and should be capable to maintain indoor temperatures. The regulation in Refrigerant flow shall be achieved by Scroll Compressors.

2.3 VRV/F SYSTEM OUTDOOR UNIT:

The Outdoor unit shall be as per IS, BS or equivalent standards as applicable.

The outdoor unit shall be factory assembled, weatherproof casing (Material of construction of casing shall be vendor's standard design), constructed from heavy gauge GI or mild steel sheet panels and coated with baked enamel finish and powder coatings. The outdoor unit shall completely consist of all variable speed compressors, condenser coil, condenser fan, factory wired, tested with all necessary controls starters, power & control wiring with Micro Processor controller in IP55 & filled with first charge of refrigerant before delivering at site. The refrigerant circuit shall include liquid and gas shut-off valves and a solenoid valves at condenser end. The equipment must have inbuilt refrigerant stabilization control for proper refrigerant distribution. All necessary safety devices shall be provided to ensure the safe operation of the system.

The Compressors shall be highly efficient hermetic Inverter Driven scroll type for variable refrigerant flow at variations on cooling loads, using the latest axial compliant sealing technology. The microprocessor panel should incorporate control for precise monitoring of status of the loads. The electromagnetic interference & conversion losses shall be minimized. All parts of compressor shall be sufficiently lubricated stock. Forced lubrication may also be employed. The Outdoor units should have minimum 2 compressors and shall be able to function with one of the compressors in failed condition and its maintenance. The outdoor unit shall be factory tested and filled with first charge of R-410a or equivalent of CFC free Eco friendly refrigerant before delivering at site. The outdoor unit shall be suitable for mix match connection of all types of indoor units. The unit shall be modular in design and should be allowed for side-by-side installation.

The condenser heat exchanger shall be constructed with seamless rigid copper tubes mechanically bonded to aluminium fins to form a cross fin coil. The fins shall treat with an anti-corrosion film. The unit should be with bye-pass or e-pass heat exchanger to optimize the path of heat exchanger. The coil arranged vertical heat discharge. The outdoor unit should be fitted with low noise aero spiral design fan with aero fitting grill for spiral discharge airflow to reduce pressure loss. Each condenser fan shall have a safety guard. The machine must have a sub cool feature to use coil surface more effectively through proper circuit / bridge so that it prevents the flushing of refrigerant from long piping due to this effect thereby achieving energy savings.

The condensing unit shall be designed to operate safely when connected to multiple fan coil units. The outdoor unit shall be properly designed for interconnecting refrigerant piping,

The outdoor units are connected to multiple indoor units of various types as such the combined operating loads of indoor units may reach 100 to 120% of the

nominal capacity. The outdoor unit shall be able to perform at the combined loads demands as indicated above.

The outdoor unit shall have properly designed with fully weatherproofed for electronic circuit and factory assembled pre-wired with all necessary electronic Micro Processor controller and refrigerant circuits, starters, contacts, power & control wiring with in IP55 protection.

The outdoor unit should be provided with duty cycling for switching the starting sequence of multiple outdoor units. The unit shall be provided with its own microprocessor control panel with provision for integration with the Building Management System for air-conditioning System.

The condensing unit fan motors to have at least two speed operations to maintain constant head pressure control in all ambient temperatures and modes of operation.

Provide the following safety devices as a part of the outdoor unit. High pressure switch, fuses, crank case heater, fusible plug, over current protector. All necessary safety devices shall be provided to ensure safe operation of the system. Following safety devices shall be part of outdoor unit, high pressure switch, fuse, fan drive overload protector, fusible plug, crank case heater, over load relay, overload protection for inverter scroll etc.

Equip the unit with an oil recovery system to ensure stable operation for systems with long refrigerant piping. Operate the oil recovery system after the first hour of operation and then every consecutive 4 hours of operation. Also fit high efficiency oil separators to the discharge side of the compressor together with factory fitted oil equalization system.

The outdoor units shall provision for side by side installation by the modular design of the condensing units with anti corrosion foundation plate for easy mounting of the unit.

2.4 CENTRAL REMOTE CONTROLLER:

Central remote controller shall be supplied as specified in the “Schedule of Quantities”

The Following functions shall be incorporated:

a) Zone control
b) Malfunction code display
c) All the functions available with wired remote controller
d) It should be possible to wire the remote to 1000 m

The system shall be equipped with a diagnostic function for quick and easy maintenance and service.

2.5 NOISE LEVEL:

The outdoor roof mounted units shall be provided in such a way that these units should not affect the overall aesthetics and ambience of the building. If required these units shall be suitably camouflaged to give good aesthetic look. These provisions however shall be discussed with users and architect for finalization.

Noise levels for outdoor units shall not be more than 67 to 70 db(A) measured at a point 1 meter in front of the unit at a height of meters. The contractor shall ensure that systems shall not cause or exceed the vibration levels and they shall be within limits as per standards. Contractor should clearly state any special treatment if necessary to achieve above noise levels.

2.6 POWER CONSUMPTION:

The total power consumption indicated shall not exceed for outdoor temperature of 45 deg C. DB and indoor temperature 24 +/- 2 deg C.DB for indicated total cooling capacity. The capacity figures may be checked by the Department at any stage during the guarantee period through its nominated inspection agency or by EIC.

2.7 REFRIGERANT:

The units should come with an initial charge of refrigerant R410a or equivalent CFC free Eco friendly refrigerant from the factory. Any additional required refrigerant shall be added at site free of cost and loss of refrigerant due to defect equipment or workmanship shall also be filled up free of cost even during the guarantee period.

2.8 REFRIGERANT PIPING DISTANCE LIMITS:

The refrigerant piping of VRV/F equipment between outdoor units and indoor units shall be extendable up to 150m or more with height difference between outdoor & indoor unit of 50m or more and the level difference between two indoor units shall be 15m or more.

2.9 REFRIGERANT PIPEWORK:

The refrigeration circuit shall be completely with condensing units, refrigerant compressors, condenser coils, electronic expansion valve, solenoid valves, distribution headers, capillaries, filters, shut down valves, service ports, receivers and accumulators and all other components which are essential for safe and satisfactory operation.

The scope of Refrigerant Piping work shall include Supply, installation, testing and commissioning all interconnecting pipe work between the condensing unit & indoor units. Use refrigerant high quality seamless copper tubes of hard and soft as required with brazed connections and the appropriate Distribution joints and headers. The refrigerant piping arrangements shall be in accordance with good engineering practice as applicable to the air-conditioning industry, and shall include charging connections. The piping should be routed at site in such a manner, that brazed joints in the Refrigeration Piping are to be minimized.

Piping shall be refrigerant grade hard and soft copper piping as required. Pipe headers, jointing, special fittings or Refnet joints shall be as recommended by VRV/F manufacturer shall be provided wherever required with factory insulated with pre-formed sections of expanded Polystyrene or equivalent.

Before jointing any copper pipe or fittings, its internals shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently it shall be thoroughly blown out using nitrogen gas.

Piping jointing shall be of the brazed type. Brazing shall be carried out to the requirements of relevant code of practice using brazing rods. Compression fittings will not be accepted on refrigerant pipe work.

The suction line pipe size and the liquid line pipe sizes shall be selected according to the manufacturer's specified diameter. The refrigerant pipes shall be phosphoric acid deoxidized seamless copper pipe suitable for R 410A refrigerant and tested as per JIS H 3300 & should have clean inner surface and capped before delivery. The brazing rod shall be hard solder, phosphorus copper solder. The following shall be the specification of copper pipes.

Size (mm)	Temper.	Thickness (mm)
6.4	0	0.8

9.5	0	0.8
12.7	0	0.8
15.9	0	1.00
19.1	½H	0.80
22.2	½H	0.80
25.4	½H	0.88
28.6	½H	1.0
31.8	½H	1.10
34.9	½H	1.21
38.1	½H	1.32
41.3	½H	1.43

All refrigerant pipes shall be properly supported and anchored to the building/structure using steel hangers, fastener, brackets and supports which shall be fixed to the building/structure by means of inserts or expansion shields or anchor fasteners of adequate size and number to support the load.

The refrigerant piping should be laid in such a way that it should not distort the interior of the room, wherever the refrigerant pipe has to be laid across the room, it should be laid in a concealed manner by making appropriate boxing arrangement matching with the interior of the room.

The supplier of air-conditioning system shall choose sizes as designed and erect proper interconnections of the complete refrigerant circuit the thickness of copper piping shall not be less than 18 SWG for pipes up to 19.1 mm and 16 SWG for larger dia.

After completion of installation of the refrigerant piping, the refrigerant piping system shall be pressure tested using nitrogen gas at a suitable pressure as specify by OEM (Original Equipment Manufacturer). Pressure shall be maintained in the system for 48 hours. After successful pressure testing the piping system shall then be evacuated to a vacuum of not less than 755 mm Hg and held for 24 hours. The vacuum shall be broken by refrigerant. This exercise shall be carried out twice before the department's representative before charging the refrigerant in the circuit.

2.10 INSTALLATION OF REFRIGERANT PIPES:

The refrigerant pipe shall be installed in good manner & support the pipe work at a minimum of 2 meter centers with suitable saddling arrangement. All pipes shall be covered with the thermal insulation & exposed refrigerant pipes on the terrace shall be provided with openable GI Cable trays / walk able platform as per drawing & SOQ.

2.11 VRV/F SYSTEM INDOOR UNITS:

The indoor units shall be of VRV/F system Dx type Hi-Wall, Cassette, Ductable Type & Treated Fresh Air units as shown in drawings. All indoor units shall be provided with Cordless Remote controllers for easy operation & setting of temperature, fan speed and louver function.

a) ELECTRONIC EXPANSION VALVE:

All the indoor units shall be fitted with an electronic expansion valve which controls the refrigerant flow in response to the load variations in the room. The electronic expansion valve is to be controlled via a computerized control sensing the return air temperature, refrigerant inlet and outlet temperatures. During the cooling operation the electronic expansion valve shall controls the refrigerant superheat degree at the evaporator.

b) INDOOR UNIT FANS:

The Indoor unit Fan shall be multi speed Direct motor driven with DIDW multi-blade type blower statically and dynamically balanced with motor & starter to ensure low noise and vibration free operation. The noise level shall not exceed 45 dBA.

c) COOLING COILS:

The cooling coil shall be direct expansion constructed from seamless rigid copper tubes mechanically bonded to aluminium fins.

d) SUPPLY AIR DISCHARGE LOUVERS:

The indoor units shall be provided with auto swing of the supply air louvers for High wall, Cassette and under ceiling type indoor units. The louvers should be capable of providing continuous swing operation and also shall able to fix in any direction as required by the user.

e) UNIT CONTROL BOARD:

The unit shall Include a printed logic circuit board complete with all accessories, switches for a various of operation controls, emergency operation switch and fault / operation indication LED's. The fan motors shall be thermally protected.

f) UNIT CASING:

The indoor unit casing for ceiling mounted units shall be heavy gauge GI sheet fully insulated and sealed to prevent condensation.

g) CONDENSATE DRAIN:

The Drain connection shall be provided of Min.25mm dia for each indoor unit to the main Header. The header pipe should be of 40mm dia. or higher the drain pipe should be of hard PVC, whereas the connection of the indoor unit to the hard PVC pipe / GI pipings shall be with flexible branded pipe. The drain piping should be insulated with 13mm. thick tubular Nitrile Rubber Elastomeric insulations to the cassette & fresh air type units. These units shall be provided with condensate drain water pump it should lift the water to the drain headers automatically the required limit switches shall be provided.

h) UNIT CONTROL:

The each unit shall have individual controller to control & set from the group controller or to control, set & address of each indoor unit from centralized controller.

i) REMOTE CONTROLLER:

Micro processed control shall be used to maintain a correct form of temperature. For the indoor units incorporate an ON/OFF switch, fan speed selector, thermostat setting with LCD/LED which shall indicates temperature setting & operational mode etc.

2.12 CEILING MOUNTED DUCTABLE TYPE & TREATED FRESH AIR UNITS:

These units shall be ceiling suspended type made of Galvanized Steel Plate with Dx type cooling coil, direct driven fan & motor, suitable supports to take care of

operating weight of the unit, canvas connections without causing any excessive vibration & noise. The cold air supplied by these units will be supplied to the area to be air conditioned, through duct system as proposed. The unit shall be supplied with fire retardant resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install.

Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling as per the heat load of the room.

The unit casing must be insulated with sound absorbing thermal insulation material, Glass Fiber. The noise level of unit at the highest operating level shall not exceed 46 dB (A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

The unit must be able to develop external static pressure of minimum 25 mm, at the specified air quantities. The Unit must have Thermal Fuse for fan motor protection, in case of motor heating.

The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded / cordless remote specified in the bill of quantities. The unit shall be suitable to connect further to the VRV/F Intelligent Microprocessor System & it shall be possible to operate the unit through PC control.

The unit shall be supplied with Drain hose, Clamps, Insulations, Sealing pads, Screws etc. The unit shall be provided drain pump its kit for suitable to lift drain water to minimum 600 mm from the drain pipe opening.

2.13 CASSETTE TYPE UNITS:

The cassette type units shall flush in to ceiling made of Galvanized Steel Plate and ABS decorative front panel with Dx type cooling coil, direct driven turbo multi speed fan & motor, electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling as per the heat load of the room. The casing shall be fully insulated and sealed to prevent condensation. The unit shall be supplied with fire retardant resin Net filter with Mold Resistance. The filter shall be easy to removable, washable & re install. The unit grille must be washable with soap solution. The unit shall have four side air flow grill be provided with auto swing of the supply air louvers. The louvers should be capable of providing continuous swing operation and also shall have provision to set air discharge angle by remote controller to fix in any direction as required by the user with suitable supports to take care of operating weight of the unit without causing any excessive vibration & noise.

The unit must be able to develop external static pressure of minimum 15 mm, at the specified air quantities. The Unit must have Thermal Fuse for fan motor protection, in case of motor heating.

The unit shall be provided with condensate drainage pump & its kit for suitable to lift drain water to minimum 600 mm from the drain pipe opening.

The unit must be insulated with sound absorbing thermal insulation material, Polystyrene / Polyethylene foam. The noise level of unit at the highest operating level shall not exceed 46 dB (A), at a vertical distance of 1.5 m from the grille of the unit.

The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities. The unit shall be suitable to connect further to the VRV/F Intelligent Microprocessor System & it shall be possible to operate the unit through PC control.

The unit shall be supplied with factory Installation panel for installation Insulation tape, Clamps, Screws etc.

2.14 HIGH WALL MOUNTED UNITS:

The high wall mounted units must be made of Galvanized Steel Plate and ABS decorative front panel along with Dx type cooling coil, direct driven fan & motor in compact & stylish design that does not detract from the décor of the room. The each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling as per the heat load of the room. The unit shall have air grill with possible to set air discharge angle by remote controller. The unit must be able to develop external static pressure of minimum 15 mm, at the specified air quantities. The Unit must have Thermal Fuse for fan motor protection, in case of motor heating.

The unit must have gravity condensate drainage provision. If required the unit shall be provided drain pump its kit. It shall be possible to fit drain pipe from either side of the unit (Left or right) at site.

Unit must be insulated with sound absorbing thermal insulation material, Polystyrene / Polyethylene foam. The noise level of unit at the highest operating level shall not exceed 25 dB (A), at a vertical distance of 1.5 m from the grille of the unit.

The unit shall be supplied with fire retardant resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install. The unit grille must be washable with soap solution.

The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities. The unit shall be suitable to connect further to the VRV/F Intelligent Microprocessor System & it shall be possible to operate the unit through PC control.

The unit shall be supplied with factory Installation panel for installation Insulation tape, Clamps, Screws etc.

2.15 CEILING MOUNTED DUCTABLE UNITS:

These units shall be ceiling suspended type made of Galvanized Steel Plate with Dx type cooling coil, direct driven fan & motor, suitable supports to take care of operating weight of the unit, canvas connections without causing any excessive vibration & noise. The cold air supplied by these units will be supplied to the area to be air conditioned directly through duct collar & grilles or through duct system specified in the tender. Each indoor unit must have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room. The unit must include as standard equipment, a drain pump & its kit for suitable to lift drain water to minimum 600 mm from the drain pipe opening.

The unit casing shall be Galvanized Steel Plate. The unit must be insulated with sound absorbing thermal insulation material, rigid glass Fiber. The noise level of unit at the highest operating level shall not exceed 48 dB (A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

The unit must be as standard equipment have provision to set external static pressure in three stages from minimum 20-25 mm depending on the air supply system. The filter shall fire retardant resin Net with mold resistant filter easy to remove, clean & re install, maintenance free long-life filter. The unit grille must be washable with soap solution.

Unit must have Thermal Fuse for fan motor protection, in case of motor heating. The unit will be connected in series to a suitable out door unit & it must be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities. The unit shall be suitable to connect further to the VRV/F Intelligent Microprocessor System & it shall be possible to operate the unit through PC control.

The unit shall be supplied with Drain hose, Clamps, Insulations, Sealing pads, Screws etc. if required as per the site conditions unit shall be provided with condensate drainage pump & its kit for suitable to lift drain water to minimum 600 mm from the drain pipe opening.

CHAPTER 3
VRV/F CONTROL SYSTEM

3.1 WIRELESS REMOTE CONTROLLER:

The wireless remote controller shall be supplied as specified in the Bill of Quantities.

The controller must have large crystal display screen, which displays complete operating status. The digital display must allow setting of temperature with 1 Deg C interval.

Remote shall be able to individually program by timer the respective times for operation start and stop.

Remote must be equipped with thermostat sensor in the remote controller that will make possible more comfortable room temperature control.

The remote shall be able to monitor room temperature & preset temperature.

Compact signal receiving unit to be mounted in the indoor units with a required hardware's.

The unit display must constantly monitor malfunctions in the system & must be equipped with a "self diagnosis function" that let known by the indication immediately when a malfunction occurs.

3.2 CENTRAL REMOTE CONTROLLER:

The Micro Processor based Central Remote controller shall be supplied with required hardware & software interconnectivity power & control cables as specified in the Bill of Quantities. The controller shall have the following provisions:

It shall control not less than 64 Groups (128 indoor units).

Zone control.

Malfunction code display.

All the functions available with wired remote controller.

It should be possible to wire the remote to 1000m.

The VRV/F system supplied must be provided with PC based air conditioning management system, from the supplier of VRV/F equipments. The required hard ware and software must be selected, suitable for up to minimum 128 indoor units.

The air conditioning management system, in broad terms must undertake following functions:

Energy efficiency functions

Control & optimization of system

Operation & monitoring

Expanded network functions

The complete operation & monitoring of VRV/F air conditioning system shall be possible to interface to the BMS.

Following major functions shall be provided in the micro processor based VRV/F central controller system:

Monitoring	Air conditioning status monitoring Indoor unit error monitoring Indoor air inlet temperature monitoring
Control, Operation & Setting	Start/ Stop control Temperature adjustment mode setting Remote control setting

	Temperature setting
Display	Air conditioner operation setting & status Set temperature Indoor unit error Indoor air inlet temperature
Measurement	Accurate operation time Number of switching times Room temperature Outdoor temperature
Printing	History Statistics Setting information
Energy management	control software & hardware shall capable to monitor total energy consumption & optimization.

The Micro Processed based centralized control system shall confirm to ASHRAE latest protocol of BACNET / LON of open type. The Micro Processed based centralized control system hard ware shall be suitable for operation between -10° C to 50° C & humidity range of 0% to 100% without condensation.

All necessary data cabling and connections shall be provided for remote monitoring and control of the complete VRV/F System.

The A/C management system must be able to connect to existing LANs.

Remote monitoring of the complete HVAC system shall be possible.

System shall be capable to take external signal like Security/ Fire for forced shut off.

4) THERMAL INSULATIONS:

The Thermal insulation for air duct & refrigerant pipes shall be of closed cell elastomeric foam insulation of nitrile rubber with temperature range of 40 deg. C to 120 deg. C with density 40-80 kg/cu.m. All insulations shall have fire performance such that it shall satisfy class 1 as per BS 476 Part 7 for surface spread of flame & also shall satisfy fire propagation requirements as per BS 476 Part 6 to meet the class 0 fire category as per building regulation.

After completion of pressure testing insulation shall be applied to the equipment and piping. Insulation material shall be as per approved makes. The entire suction and liquid refrigerant pipe lines including all fittings, valves and strainer bodies etc shall be insulated with 25mm thick and the drain piping should be insulated with 13mm thick elastomeric Nitrile rubber thermal insulations .

To provide mechanical strength and protection from damage all pipe / duct insulated with nitrile rubber as indicated in BOQ shall be covered with woven 100 GSM GRP mat covering or self adhesive fiberglass cloth of 7 mil. thickness for internal pipes .The external pipes shall be further protected with 26G aluminium sheet cladding for mechanical & weather protection and should run on GI tray . The adhesive used shall be SR 998 / SR 505, Armaflex 520 and the insulation shall be covered with Nitrile rubber tape of Armaflex or equivalent.

CHAPTER 4
ELECTRICAL WORKS

1) SCOPE:

This part defines the scope of design, manufacture, supply, delivery, installation, testing, commissioning, start-up of all electrical equipment and accessories required for the Systems.

All equipments, control and instruments etc. to be supplied against this contract shall be of proven design by way of actual field operation without any deficiency or problems whatsoever.

The complete electrical work shall have the approval of Electrical Inspectorate of respective state, Fire Regulation Authority and other local agencies, besides purchaser's engineers. Approvals shall be obtained in writing by vendor from these respective authorities prior to commissioning.

2) EQUIPMENTS TO BE SUPPLIED BY VENDOR:

Main supply cubical distribution panel shall be as per approved makes along with necessary SFU, indication lamps starters, S.P.P. and other safety protection devise controls including interlocking.

Local power and control cubical panel including switch fuse unit, starters, SPP, contractors and earthing with provision for supply to various controls for the entire system.

T.E.F.C. squirrel cage induction motor in conjunction with respective driven equipment of specified make.

Supply, installation and termination of power and control cables between panels and various equipments with earthing.

Supply, installation and termination of earthing conductor for individual equipment for grounding.

Cable, lugs, clamps, clamps glands, etc.

Power and control cable trays for routing the cables from main distribution board to various local panels & equipments.

The electrical equipments and materials shall be supplied by vendor shall meet the requirements as mentioned in subsequent clauses.

3) SQUIRREL CAGE INDUCTION MOTOR:

a. GENERAL:

The induction motors shall be designed, constructed and tested in accordance with this specification and be suitable for continuous operation at the ambient condition mentioned.

b. STANDARDS:

The motors shall confirm with the following Indian Standards unless otherwise explicitly specified herein:

IS:	325	Three phase indication motors
IS:	4691	Degree of protection provided by enclosure for rotating electrical machinery
IS:	3202	Code of practice for climate proofing of electrical equipment
IS:	4728	Terminal marking and direction of rotation for rotating electrical machinery
IS:	4029	Guide for testing three phase induction motors
IS:	4729	Measurement and evaluation of vibration of rotating electrical machines

IS:	4889	Methods of determination of efficiency of rotating electrical machines
IS:	2253	Types of construction and mounted induction motors
IS:	4722	Rotating electric machines
IS:	7816	Guide for testing IR of rotating machines

c. TECHNICAL PARAMETERS:

System voltage	:	415 ± 10% , 3 phase, 3 wire effectively earthed (with 3% unbalance in voltages)
Frequency	:	50 Hz ± 5%
Enclosure	:	TEFC as per IS :325
Starting	:	Direct-on-line below 7.5 HP accelerating at 80% voltage at the terminals
Pull out torque	:	200% at rated voltage (for short duration of 25-30 cycles if voltage drops to 75% of nominal motors shall pull out of step).
Degree of protection	:	IP 55 for all the pumps motors
Winding insulation	:	Class F maximum winding temperature 150 deg. C. on full load at any point of winding including single phase FHP motors
Space heaters	:	240 V 01 phase 50 HZ thermostatically controlled to keep the winding temperature 5 deg. C above ambient for motors above 10 KW.
Bearing	:	Antifriction ball or roller type for 1000 RPM up to 50 BHP motors sleeve bearings with two oil rings, lubricated for higher BHP motors. Vertical motors shall be provided with thrust and guide bearing
Mounting	:	Foot mounted, horizontal (unless otherwise specified).
Starting duty	:	Capable of at least 2 successive starts and third start after an interval of 15 minutes
Terminal boxed	:	Large enough for alum. Conductors with six terminals to be brought and shorted with heavy gauge tinned copper plate for DOL or star delta.
Star delta motors & DOL motors	:	2 Nos. & 1 No. brass cable gland for DOL motors. Terminal box shall be suitable for top and bottom entry of cables.
Rotation	:	Be capable of rotating on forward and reverse direction

d. CONSTRUCTION:

The motor shall be so constructed that efficient cooling is achieved to keep the temperature rise with in permissible limits as well as withstand the effect of abnormal operating conditions for a short period on infrequent basis without any damage or deterioration on the life and performance.

The design and manufacture shall be coordinated and approximately matched with the requirements of the driven equipment both mechanically and electrically. The motor frame shall be either fabricated or casting of approved quality.

The end windings of the tarter and rotor shall be properly braced and supported to cater for the various operation / starting conditions as well as the effect of the bus transfer.

The motors shall be high efficiency (No less than 95%) squirrel cage type and the design shall provided a rigid cage construction with base firmly webbed in sloter and solidly bonded to the end rings. The motors shall be capable of withstanding without mechanical damage at least 125% rated speed which may be imposed by the driven equipment in both direction of rotation.

The main base frame shall have two ground terminals for earthing the motor with ground network by appropriate size conductor as specified in earthing clause.

The terminals shall be fitted with tinned copper serrated short barrel lugs. For belt driven motors or directly coupled machines protective covers/ guards shall be supplied for the whole assembled unit. Adjustable slide bases or rails shall be provided for all motors where belt or chain drives are used.

e. INSPECTION & TESTS:

All motors shall be inspected at various stages of construction by purchaser and tests will be witnessed prior to acceptance. Manufacturer shall notify purchaser the schedule of manufacture to arrange stage wise inspection.

Routine tests shall be conducted on all motor and type tests as per IS : 325 & IS : 4029 will be carried out on one motor of each type.

Six copies of test certificate shall be submitted to purchaser for records.

4) DRAWINGS:

General arrangement drawings, mountings details, foundations, terminal box drawings shall be furnished to purchaser for approval prior to manufacture. Approval drawings sets shall be furnished for purchaser's records.

5) INSTRUCTION MANUALS:

Supplier shall submit 5 copies of instruction manual covering installation, operation and maintenance of motors which shall include procedure for checking alignment of motor shafts, coupling and base. Instruction shall also include lubricating details, inspection and replacement schedules, quantity of lubricant required and its specifications.

6) STARTERS

a) Motors below 7.5 HP shall have direct on line staring arrangement with in rush starting current of seven times full load current.

7.5 HP and above motors shall be started on reduced voltage by means of automatic star delta starter. C.T operated ammeters shall be provided on all phases on these meters.

The design, manufacture and testing of the starter components and whole assembly shall confirm with the following Indian Standards except for the specified deviation outlined in this specification.

IS :	2705	:	Current transformers
IS :	2208	:	HRC Cartridge Fuse Link up to 650 V
IS :	4794	:	Push Button Switches
IS :	1336	:	Recommendations for colours of Push buttons
IS :	8623	;	Factory-built Assemblies of switchgear

IS : 6005 : Code of Practice for phosphating Iron & Steel
IS : 604 : PVC insulated copper cables

Voltage 415 ± 10% 3 Phase 4 wire
Frequency 50 HZ ± 5%
Control voltage 240 V± 10% (tapped between phase & neutral)

Each starter shall be provided with following protective devices:
Manual reset type bimetallic thermal overload relay on all the phases.
HRC fuse protection on power and control circuitry
Single phase preventor for motor above 7.5 HP shall be provided
Under Voltage protection

b) CONTACTORS:

Contactors shall be 3 pole air break type electro- magnetic rated for 120% of the respective load current confirming to Ac-3 duty as per IS : 2959. The coil voltage shall be 240 ± 10% and be insulated with class-B material, 2 No's ± 2 NC's spare auxiliary contractors shall be provided exclusively for purchasers use for remote control or alarm / annunciator purposes. The drop off voltage of contractors coil shall be 40-60% of rated voltage. The main contacts will be silver plated. Contractors shall be devoid of humming noise. The make contractors shall be "Siemens' or 'Andrew Yule' or 'Cutler Hammer' or 'Larsen & Toubro'

c) FUSES:

All fuses shall be of high reputing capacity with duty category of 80 KA as per IS : 2208. Diezd fuses shall not be accepted. Fuses shall be either 'English Electric' or 'Siemens make' Two fuse puller for each type of fuse shall be supplied, wherever required.

d) OVER LOAD RELAY:

The thermal overload relay shall be triple pole, bimetallic ambient temperature compensate with built-in single phase preventor for and auxiliary contacts of 5A rating at 240 V AC. The relays shall withstand the net through energy of associated fuse caused by short circuit current.
The overload relays shall preferably be 'Culter Hammer' make. For longer duration starting time motors, saturable C.T. operated type overload relays shall be used. The over load relay setting range shall be between 70% to 120 % of respective motor load.

e) PUSH-BUTTON ELEMENTS:

Push button shall be rated 6A, 240 V, AC spring loaded with 'NO' contact for starting and 'NC' contact for stopping. Stop push button shall be recessed type 'red' colour and start push button Mushroom type 'Green colour' A locking arrangement shall be incorporated on the enclosure in the form of a sliding latch which will keep the knob pressed. The latch shall be made of Chromium passivated M.S. strip.

f) AMMETERS:

The ammeters shall be taut band suspension square pattern 144 X 144 mm 240 deg. C scale, flush mounted and shall be moving iron type of metering class accuracy. Indication lamps shall be of filament type having double contact bolyonet taps and low watt consumption. This shall be provided with series resistance.

g) ENCLOSURE:

The starter enclosures wherever separately mounted, shall be made of 14 SWG CRCA sheet steel and shall be totally enclosed neoprene gasketted metal clad, dust and vermin proof. Conforming to IP 54 as per IS : 2147, inscription plate shall be provided under the push button knobs having appropriate start or stop nomenclature. Besides a separate black name plate or black lamicoid material shall be screwed on to case starter indicting the tag No. of the motor being controlled. The cable entry shall be through compression type chromium plated brass cable glands.

h) TERMINAL BLOCKS:

The terminal blocks shall be bolted /clamp type of Elemex make and the rating shall be as under.

Power – Suitable for load as per feeder current with minimum rating of 15A. The connections shall be crimped type, tinned copper lugs.

Control – Suitable for 2.5 sq. mm copper conductor. 15% extra terminal shall be provided.

i) WIRING:

The various sizes of internal cabling shall be as follows :

Power – Standard copper conductor PVC cable of appropriate size.

Control circuit – 2.5 sq. mm. copper conductor PVC cable circuit.

j) PAINTING & FINISHES:

The starter and the frame work shall be painted with two coats of air craft grey colour of shade No. 693 as per relevant over two coats of primer after thorough pretreatment of degreasing, pickling and phosphating.

k) INSPECTION & TESTING:

The following tests shall be conducted on each starter.

--- Visual check.
--- High voltage tests.
--- Insulation resistance test with a 500 V megger.
--- Operation tests.

7) POWER AND CONTROL CABLES:

a) Design, manufacture and testing of power and control cables shall be in accordance with the following Indian Standards.

IS : 1554		PVC insulated electric cables (Heavy duty)
IS : 694 (1)		PVC insulated cable with copper conductor
IS : 8130		Conductors for insulated Electric cables
IS : 3975		Mild steel wires for armouring cables
IS : 5831		PVC insulated and sheath of Electric cables
IS : 3961		Recommended current rating of cables

b) TECHNICAL PARAMETER:

System voltage	-	415 $\pm$ 10% phase (power cables) 240 $\pm$ 10% , 1 phase (Control cables)
Frequency	-	50 Hz $\pm$ 5%
System Fault level	-	35 MV for 1 sec.
Insulation level	-	1100 V grade (power cables) 650 V grade (Control cables)

Conductor temperature	-	150 deg. C (Maximum) while operating on full load prior to short circuit.
Type of conductor	-	¾ Hard drawn annealed standard aluminium conductor for power cables Hard drawn solid copper conductor for control cables
G.I. Armouring	-	Strip / Wire (As per IS 1554 part-I)

c) CONSTRUCTION:

All cables shall be manufactured from first quality materials, free from any defects. The conductor shall be copper or aluminium as specified, insulated with tropical grade appropriate colour, code, polyvinyl chloride compound, laid together and surrounded by extruded PVC common covering i.e. leather sheath followed by galvanized wire armouring with overall jacked of black PVC compound. Manufacturers name, voltage grade etc. shall be embossed at regular intervals throughout the length of the cable.

d) INSPECTION AND TESTS:

Following routine tests shall be carried out on each type length of cable.

--- Resistance test
--- Insulation test
--- High voltage test

Type test certificates shall be submitted for each type of cable.

8) EARTHING:

Earthing system and material shall conform to IS : 3043. The earthing conductor shall be of electrolytic copper as per I.S. shall provide for grounding of each equipment including structure, vessels, tanks etc. Each electrical equipment shall be grounded by two separate and distinct connections as per IE rules. Earth continuity shall be maintained through any metallic conduit run.

SIZE OF COPPER STRIP / WIRES FOR EARTHING:

Earthing of cables shall be carried out as under:-

Sr.No.	Size of cable	Size of copper/switches.
1.	a) 10 sq.mm/4 core b) 16 sq.mm/4 core c) 25 sq.mm/3 ½ core d) 35 sq.mm/3 ½ core	2 nos. of 8 SWG copper.
2.	a) 50 sq.mm/3 ½ core b) 70 sq.mm/3 ½ core c) 95 sq.mm/31/2 core	2 nos of 4 SWG copper.
3.	a) 120 sq.mm/31/2 core b) 15 sq.mm/3 ½ core c) 185 sq.mm/3 ½ core	2 nos of 25 x 3mm copper.
4.	a) 225 sq.mm/3 ½ core b) 300 sq.mm/3 ½ core	

c) 400 sq.mm/3 ½ core	2 nos of 25 x 6 mm copper
d) 500 sq.mm/3 ½ core	

Earthing conductors will be tested for all routine tests as per relevant IS. The earthing system shall be tested by meggar and measurement shall be recorded and submitted for department's approval.

8) ACCESSORIES:

Cable lugs, clamps, cable glands etc.

The cable lugs shall be tinned copper and soldering / crimped type of Dowell's or equivalent make. Petroleum conducting jelly shall be applied on inner surface for better conductivity and to prevent corrosion at contact surface. For cables up to 95 sq. mm. cables sockets can be crimped type and for size above 95 sq. mm. the lugs shall be soldered type.

Galvanized clamps for supporting cables, conduits etc., shall be of appropriate type sample to be got approved. Galvanized horizontal or vertical cable trays shall be used as per instruction of E-I-C. PVC chord (8mm dia minimum) shall be strapped instead of clamps or saddles.

Compression type brass cable glands shall be used for cable terminations. The cable glands shall be of Siemens make or equivalent, tinned copper earthing clamps of adequate size shall be provided and connected to earth bus.

The conduits shall be heavy gauge, solid drawn ERW, conforming to IS: 1653. Each length of conduit shall have manufacturer's trade mark or name embossed. All burrs shall be removed at the end to prevent abrasion of cable. Bending of conduits shall be by means of manually or hydraulically operated bending machines to gives bending radii of 10 -12 times of the OD of the cables depending upon the sizes. Bends shall be free from cracks and kinks.

The number of wires drawn in conduit as per table indicated in drawing. For size of wires not indicated in table, E-I-C shall be consulted & work to be executed accordingly.

10) INSTALLATION OF EQUIPMENT'S:

a) Installation of various electrical equipments and accessories shall be in accordance with relevant standards, code of practice and regulation as mentioned below:

IS: 732 : Code of practice for electrical wiring installation up to 650 V.
IS : 2274 : Code of practice for electrical wiring installation up to 650 V.
IS : 1646 : Code of practice for fire safety of buildings (General) Electrical installation.
IS : 5908 : Method of measurement of electrical installation in building.
IS: 3043 : Code of practice for earthing.
IS : 5216 : Guide for safety procedures and practices in electrical works.
IS : 900 : Code of practice for installation and maintenance of A.C. induction motors.
IS : 5224 : Code of practice for installation and maintenance of A.C. induction motor starters up to 1000 V.
IS : 5561 : Electric power connectors.

IS : 1554: PVC insulated (heavy duty) electric cables for working voltages (Part-1) up to and including 1100 V.

Regulation : Indian Electricity Rules Factory Act & Regulations & other statutory & Rules local, State and Municipal Regulations. National Electrical code –1980.

b) GENERAL:

Packing materials, rust, oil or grease shall be removed from equipment prior to installation. Manufacturer recommendation as stipulated in their manuals and guideline given in subsequent clauses of this specification will be followed for installation, testing and commissioning of all the equipment. The contractor shall guarantee the installation for a period of 12 months from the date of acceptance after commissioning. Any damage or defect that may arise or be discovered or in any way be connected with the equipment or materials supplied by him or in the workmanship will be rectified or replaced by the contractor at his own expenses as deemed necessary by the owner.

In order to meet the above guarantee, good workmanship shall be the essence of installation work. As such the contractor shall employ adequate number of competent and certified personnel at site, besides qualified and experienced engineering supervisors on full time basis for inspection and supervision of work being executed. The contractor shall furnished list of team to be employed for the job along with names, specification and experience.

c) MOTORS:

All motors shall be mounted on a common foundation with the driven equipment either directly coupled or through bell drive. Installation shall be in accordance with IS : 900. Flexible connections shall be provided to all motor terminals whenever the motor is mounted on guide rails for belt drive motors. The connections shall be flexible enough to prevent transmission of vibration. All drive arrange arrangement and couplings shall be provided with a safety guard.

All motors shall be provided with two no separate earth connections of size specified in technical parameters.

d) STARTERS:

The starters shall be installed in accordance with IS : 5124. The starters shall be mounted securely in accessible location on the panel or wall near the motor at a height of 1500 mm. Design of steel brackets and support for mounting of starters shall be of approved quality and shall be painted with epoxy paint after through pretreatment on completion of fabrication. For all outdoor installation G.I. enclosure shall be provided. The starter shall have push button stations for motor wherever required.

Internal wiring and mechanical operation shall be checked including setting the protection relays.

All power and control cable connections including earthing connection shall be completed.

e) CABLING:

All cables shall be laid in neat and orderly manner by skilled experienced and competent workman in accordance with standard practices. All cables shall be carefully handled specially avoiding rubbing against sharp edges in the working area. Bending of cables shall be 10-12 times the overall dia

of armoured cables. This shall be taken care while unwinding and laying the cables in trays or conduits etc.

Each cable shall be tagged at both ends with tags made out of aluminium strips and designation shall be in accordance with cable schedule.

All cables irrespective of type of installation shall be protected by means of G.I. pipe class B conduit or sheet steel ducts up o a height of 2000 mm from floor and platforms for protection against mechanical damage.

Cables shall be laid in one piece length and no joints shall be allowed. At the cable ends suitable loops of at least one meter length shall be kept for future requirements. Ends of cables shall be properly sealed to prevent entry of moisture prior to installation. Cable termination shall be done with suitable compression type brass glands. The armour shall be connected to the earth conductor. The insulation over each conductor up to the end where lugs shall be stripped thereon for connection. All connections shall be equipped with two plain and one spring washer to make vibration proof. Cable jointing shall be using soldering type cable sockets for cables above 95 sq. mm. size crimping shall be done by means of hydraulic crimping machine. Method of installation routing of cable etc. shall be subject to the approval of purchaser and there shall be minimum interference with build up areas etc. The cables laid in built up trenches shall be properly fixed with angles iron /trays etc. depending upon the number of cable.

The cables laid on cable trays shall be dressed neatly avoiding cross crossings of cables and strapped on the trays at an internal of 1000mm. Power and control cables shall be separately segregated and laid. Power cables shall be laid in one layer only.

Cables or group of cables when run on structures etc. shall be provided with saddles and clamps. Clamps shall be spaced at 750mm. For vertical runs and 500mm for horizontal runs.

f) TOOLS AND INSTRUMENTS:

The contractor must possess necessary tools, tackles, instruments and machines (on hire or otherwise) for carrying out the installation and commissioning work.

11) INSPECTION, TESTING & PRE-COMMISSIONING CHECKS:

a) GENERAL:

After completion of installation work but before switching 'ON' all necessary visual /physical checks and tests shall be conducted by the contractor on each of the equipment system installed by him to ensure that complete installation conforms to IE rules and other statutory authorities.

The checks and tests shall be in accordance with the guidelines / schedule indicated here and shall cover all necessary adjusting, setting, coordination and calibration jobs. Any other test or repetition of any test, if required by the Electrical Inspector or any other statutory authorities prior to approval of installation shall be carried out by the contractor at no extra cost to the owner.

On satisfactory completion of testing and obtaining of necessary Electrical Inspector's statutory approval, the contractor shall render all necessary assistance to owner in commissioning the installation.

On satisfactory commissioning of the installation, the contractor shall submit to owner 'Certificate' of test and completion in triplicate on

prescribed form duly countersigned by owner's authorized Engineer for the installation within 3 days of commissioning of installation.
All testing shall be scheduled by the contractor with approval of owner.
No testing shall be done in absence of owner's authorized representative.
No high voltage test shall be carried out without specific permission of owner. All temporary arrangements circuit simulation and connections required for testing shall be done by the Contractor at no extra cost to owner.
Complete personnel safety and prevention of equipment damage during carrying out any test, the earthing system shall be checked and tested satisfactorily. If desired by the owner, the contractor shall submit for conducting any tests.

b) VISUAL INSPECTION:

Such checks on all equipment's components shall generally be carried out in line with manufacturer's instructions, relevant standards / code of practices good engineering norms. However the specific points enumerated below shall be followed.

c) MOTORS:

Proper Alignment.
Direction of rotation.
Adequacy of bearing lubrication based on manufacturer's recommendations.
Tightening of all loose connections.
General checking to ensure that the motor is in satisfactory condition for testing and commissioning.
If possible, uncoupling the motor from driven equipment before energizing.
Earthing termination.

d) STARTERS:

Cleaning and adjustment.
Tightening of all loose connections.
Continuity of all auxiliary and control circuits.
Tightness of enclosure earth connections.
Operation of all switches, push buttons, SPP and other controlling devices.
Earthing termination.

e) TESTING & PRE-COMMISSIONING CHECKS:

For all equipment, pre-commissioning site tests shall be carried out by the contractor in line with the procedure / recommendations of relevant IS or manufacturer's instruction. However, specific points mentioned below shall in any case followed.

f) INSULATION RESISTANCE (MEGGAR) TEST:

Meggar tests wherever specified shall be applied only to the particular equipment which is to be tested. This equipment shall be disconnected from an other equipment which may damaged by such tests. The meggar test shall be applied to rotating machines for three minutes and reading shall be taken at one minute intervals for three minutes.

g) HIGH VOLTAGE TEST:

High Voltage tests shall be carried out at specified voltage for a period of one minute in the presence of owner's engineer as per relevant I.S.

Prior to any high voltage test, a meggar test shall be made on the equipment which should indicate a satisfactory minimum acceptable IR Value.

After marking high voltage test, another meggar test shall be made on the particular equipment and minimum acceptable values as indicated by owner'

h) ACCEPTANCE:

Owner's provisional acceptance of the installation shall be subject to satisfactory materials and workmanship, successful completion of checks and tests, demonstration of satisfactory start up / commissioning and submission of proper ' Certificates' of test and completion to the complete satisfaction of E-I-C.

12) CABLE TRAYS (SPECIFICATION-TECHNICAL REQUIREMENT)

a) SCOPE:

This specification covers the design, manufacture, testing packing and delivery to site and installation of G.I. cable pans, accessories and cable pan supports. The design manufacture, identification and testing installation of the material covered by this specification shall comply with the latest revision of the relevant Indian Standards unless otherwise stated in this specification. The cable pans shall be fabricated out of G.I. sheets free from any flaws. The M.S. sheet used for fabrication shall conform to the latest provision of Indian Standard IS: 1079.

b) PERFORATED TYPE CABLE PANS AND ACCESSORIES:

1.	Cable pans	:	Channel shaped side with bottom perforated G.I. Sheet fabricated out of 12 SWG (2.64 mm) single M.S. sheet
2.	Accessories	:	Channel shaped side members with bottom of perforated M.S. sheet
3.	Side members of accessories	:	Channel forms fabricated out of 12 SWG (2.64mm) G.I. Sheet.
4.	Bottom member of	:	12 SWG perforated G.I. sheet with perforations as pr instructions of E-I-C.
5.	Fixing of bottom members to side members	:	Nut bolting
6.	Fabrication	:	Perforations, Burns and sharp edges shall be filled after perforating the sheet and the surface shall be smooth to prevent damage to cables.
7.	All corners	:	Smooth with radius not exceeding 6 mm.
8.	Dimensions & Details	:	As per requirements.
9.	Straight length of cable pan	:	As per requirement (but not more than 2.5 mtrs.)
10.	Holes for clamping side	:	Two 12 mm dia. Holes at either end of pans and accessories.
11.	Drilling of side	:	5 mm diameter tapped holes are to be provided in the top of the side members as per instructions of E-I-C for all the pans and accessories.

12.	Drilling of side members for grounding conductor & connectors	:	12mm diameter holes are to be provided.

13) SIDE COUPLER:

Each 2.5 M section of all types of cable pan and each elbow, tee, cross. Etc. shall be provided with side coupler plates and associated bolts, nuts and washers. The side couplers shall be fabricated from 14 SWG (2mm thick) G.I. sheet strips with two circular holes and two elliptical holes. Detailed dimensions of the strip, centre line of holes, nuts and bolts are as per instruction of E-I-C.

14) CABLE COVERS:

Bidder shall supply sheet steel covers for cable pans and fittings where specified.. The covers shall be fabricated out of 16 gauge (1.6mm thick) M.S. sheet, cable pan covers shall be the same width as the cable pans. Suitable screws with washers shall be supplied for fixing cable pan covers to the cable pan elbow, reducers, tees, crosses etc. Welding if required shall be in accordance with the latest revision of Indian Standard IS 813 and IS 816. All fabricated components shall meet the material requirements of latest revisions of relevant Indian standards.

15) GALVANIZING:

All cables, pans and accessories including coupler plates etc. shall be hot dip galvanized after fabrication according to the latest revisions of IS 2629, 2633, 4759. The galvanizing shall be uniform clean, smooth, continuous and free from acid spots. Should the galvanizing of the samples of found defective, the entire batch of steel shall have to be re-galvanized a suppliers cost. The amount of zinc deposits shall not be less than 610 grams per square meters of surface area and in addition the thickness of the zinc deposit by an Elko meter or any other instrument acceptable to Purchaser and reject any component which shows thickness of zinc at any location to be less than 75 microns.

At any spot whatsoever, shall not be less than 75 microns, for all cable pans and accessories excepted for covers. For covers the zinc deposit shall not be less than 460 grams square meters of surface area and the thickness of zinc coating shall not be less 60microns. The purchaser reserves the right to measures the thickness of zinc deposit.

Holes on all cables pans for fixing covers shall be cleaned and proper for accepting screws. The amount of zinc deposit over threaded portion of bolts nuts and screws shall not be less than 300 grams per square meters of surface area. The amount of zinc deposit for washer shall be not less than 340 gm / sq.m surface area.

Nuts, bolts, screws and washer shall be zinc electroplated in accordance with relevant standard.

16) INSPECTION AND TESTS:

All material and equipment furnished and work performed shall be subject to rigid inspection by the purchaser. The supplier shall perform all the routine tests and inspection to ensure that material and workmanship are according to the relevant standards. Following tests in addition to the tests specified in relevant standards shall be conducted in the presence of purchaser's representative on the samples selected randomly from each set.

Visual Inspection,Dimensional checking.
Copper sulphate Test (Uniformity test)
Zinc coating thickness check.
Tripping test.

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CHAPTER 5
TECHNICAL DATA SHEETS TO BE SUBMITTED BY THE BIDDER

Sl. No	Description	Information to be fill by the Bidder
A	**Outdoor Units of VRV/F Systems**	
1.	Make & Model	
2.	Capacity (TR / HP and nos. of compressors)	
3.	Supply & operating weight	
4.	Overall Dimension	
5.	Compressor	
	a) Model	
	b) Type	
6.	Name of refrigerant	
7.	Compressor Power consumption in kw	
8.	Power requirement for VRV/F system outdoor units	
B	**Details of Cassette type Indoor units**	
1.	Make	
2.	Model	
3.	Capacity inTR	
4.	Unit Size	
5.	Refrigerant pipe size (liquid & gas)	
6.	Power requirement (single phase AC)	
7.	Remote control details	
8.	CFM	
9.	Air filter details	
12.	Drainage pump details (whether provided)	
C	**High wall type VRV/F Indoor units**	
1.	Make	
2.	Model	
3.	Capacity in TR	
4.	Unit Size	
5.	Refrigerant pipe size (liquid & gas)	
6.	Power requirement (single phase AC)	
7.	Remote control details	
8.	CFM	
9.	Air filter details	
13.	Drainage details	
14.	Total weight of unit	
15.	Mounting details	
D	**Treated fresh air unit**	
1.	Make	
2.	Model	
3.	Capacity	
4.	Unit Size	
5.	Refrigerant pipe size (liquid & gas)	

6.	Power requirement (single phase AC)	
7.	CFM	
8.	Air filter details	
	c) Drainage details	
12.	Total weight of unit	
13.	Mounting details	
E	**Refrigerant piping material**	
1.	Headers	
2.	Distribution pipes	
F	**Insulation details for refrigerant piping & condensate piping.**	
1.	Material	
2.	Make	
3.	Thermal conductivity	
4.	Thickness	
G	**Air Duct**	
1.	Air Duct material	
2.	Supply air grill / diffuser size	
3.	Return air grill / diffuser size	
H	**Electrical panel details**	
1.	Manufacturer	
2.	Overall size of the panel	
3.	Type & IP rating of the panel	

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Part 3
Technical Specifications for Unitary AC System

CHAPTER 1
GENERAL CONDITIONS

1. SCOPE OF WORK

The scope of work includes Design, Supply, Packing and transportation to site, loading and unloading, handling of equipment at site, erection, Installation, testing, commissioning into service, carrying out all the acceptance tests and handing over the Split Air conditioning System with Guarantee as per the Schedule of Quantities and technical specifications, all as per the standards and codes of the Bureau of Indian Standards / other relevant standards and entire satisfaction to Engineer in charge.

The contractor shall calculate equipment capacity based upon design parameters specified for the system design & verify all the quantities and sizes of refrigerant pipe, fitting & cables, control cable, pipes, insulations, indoor units, outdoor units etc. before placing the order to avoid any shortfall or surplus. The tenderer shall include all necessary civil work and MS frame work for installation of outdoor and indoor units of air-condition system for proper & specified functioning.

The Contractor shall include all the labor required to install all materials, appliances, equipment necessary for the completion, and testing of the System as specified in the approved drawings and Schedule of Quantities. The work shall include all incidental jobs connected with System installation such as breaking the walls and finishing back as well as cutting, drilling in civil structures for refrigerant piping and equipment electrification work etc.

The allied Scope of works consists of Engineering proposals, Preparation of shop drawings, Design and selection calculations of all systems etc. The Contractor shall responsible for the protection of all materials and equipment during storage construction until handing over also responsible for final exterior and interior cleaning of the equipment systems etc. Contractor shall submit the specified tests inclusive of necessary reports, Brochures of equipments and Maintenance Manuals and Performance Guarantees certificates. Monitoring of all works for workmanship and technical compliance to ensure the work conforms to the approved shop drawing details & specifications. The modifications made during execution shall be up to the acceptable standards. The Contractor shall co-ordinate the various activities with other Contractors and Vendors involved in this project.

2. REFERENCES AND STANDARDS

The supply, installation, testing and commissioning of the equipments, systems, materials, accessories etc. shall comply with the latest applicable relevant standards of IS, BIS, ISO, BS, ARI, AHRI, ASME, ANSI, AMCA etc. and codes of practices.

3. GUARANTEE

The contractor shall be fully responsible and guarantee proper design and performance of his installed system. The Contractor shall indemnify and save harmless the Consultants and Employer in consequence of the design for the manufacturing defects, patent manufacturing defects, construction defects etc, If found any such shall be rectified at free of cost.

The contractor shall also seek warranty for installed plant from the OEM equipment supplier. The Contractor shall ensure that the OEM norms for supply, installation, testing and documentation as specified by the OEM supplier shall be adhered to, provided those are in line with the relevant standards and as per the approval of Consultants. The warranty shall be provided by the OEM vendor to the Employer and shall be administered in India, and shall cover the system performance.

4. CONTRACTOR'S RESPONSIBILITIES

Contractor shall Responsible for Design and Execution. The Drawings and specifications indicate the required basic design intent and general performance criteria. The contractor shall have the option of modification and addition of details provided the over-all concept and performance requirements are fulfilled. The proposed modifications shall be clearly shown on the shop drawings as "Design Modifications" and acceptance of the same will not relieve the contractor from sole responsibility for performance of the systems shown on the Schedule or described herein, properly connected and in working condition. The Contractor shall be solely and fully responsible for due performance of his installation based on the design and details. Engineer in charge clearances will not relieve the contactors responsibilities.

Engineer in charge will have the right to reject any and all components and assemblies during assembly and erection if the workmanship and intent are not in strict conformity with the approved shop drawings and specifications.

5. SHOP DRAWINGS

The tender drawings are preliminary conceptional layouts only. Contractor shall prepare necessary detailed engineering drawings based on the preliminary drawings and two (2) copies of all shop drawings shall be submitted to the Engineer in charge for the approval. The shop drawings will not relieve the contractor from any of his responsibilities and requirements as stated in the Contract Documents. No work shall be fabricated until the shop drawings and

all other related submissions, documentation, certifications, samples and the mock-up for that work have been reviewed and approved by the Engineer in charge.

The Engineer in charge review of all the work shall be installed as indicated on the drawings, however any minor changes found essential to co-ordinate the installation of this work with the other trades shall be made without any additional cost to the department. The tender drawings are for guidance of the Contractor and exact locations, distance, and levels will be governed by the site conditions. The Contractor shall examine all architectural, structural, electrical, sanitary, fire-fighting systems and their hindrances etc.

6. DESIGN CALCULATIONS

The contractor shall submit his detailed design calculations for the systems and each of their components and shall guarantee that his design will ensure the safety and integrity of overall system.

Contractor shall submit the design calculations in Three (3) sets and get approval from engineer in charge. However the Contractor alone shall be responsible for design calculations for the systems and workmanship of fabrication and installation. If any modification were required in the design shall be brought to the notice to the engineer in charge.

7. SAMPLES AND MANUALS

After of issue of work order, the samples of actual job site materials with detailed technical data / catalogues shall be submitted in triplicate to engineer in charge review and approval as required under relevant sections.

All materials and equipment shall conform to the relevant standards and shall be of the approved make and design. Unless otherwise called for, only the best quality of materials and equipment shall be used. All materials proposed to be used for the project shall be new and un-used materials only. The Contractor shall be responsible for the safe custody of all materials and shall insure them against theft, damage by fire, earthquake etc. A list of items, materials and equipments brought to site shall be submitted to the engineer in charge.

8. WORK SCHEDULE

On the receipt of the work order, the Contractor shall submit the detailed schedule for the completion of the works including all activities and stages of the work such as submittals, approvals, fabrication, supply at site, installation, testing and commissioning. The time schedule shall be got approved from the engineer in charge.

The time schedule shall be prepared in consultation with the engineer in charge to suit the overall project schedule and shall be updated from time to time to suit prevailing conditions.

The Contractor shall carry out his work in such a manner that the work of other agencies operating at site shall not hamper due to any action of the contractor. Proper co-ordination with other agencies will be his responsibility. Contractor shall ensure that the work of other contractors is not held up due to non-completion of his part of work. In case of dispute the decision of the engineer in charge shall be final and binding on the contractor.

9. INSPECTION OF EQUIPMENT, COMPONENTS, SYSTEMS AT MANUFACTURERS PLACE.

The contractor shall submit a schedule of material specification and procedure for inspection of quality of equipment, components, and systems during the fabrication, manufacturing in the plant.

The Contractor shall submit fortnightly reports on the results of the inspection of the components. The Contractor shall submit a description of the procedure of delivery, hoisting, storage, handling, fixing, and temporary working stage, protection and cleaning. The Contractor shall give due notice to the engineer in charge in writing whenever any work is to be buried in the earth or made inaccessible later on, in order that the work may be inspected and correct dimensions taken before such burial takes place. The Contractor shall maintain a site order book at the site of works. Where manufacturers have furnished specific instruction relating to the materials used in this job, covering points not specifically mentioned in these documents; these instructions shall be followed in all cases.

10. GENERAL CONDITIONS FOR TESTS TO BE CALLED FOR APPROVAL PURPOSE

The contractor shall carry out in the presence of engineer in charge all specified tests. Such tests shall be carried out at the manufacturer's works or at the works of the contractor for approval.

The Contractor shall then forward all the relevant copies of Test Certificates so performed for the record of the engineer in charge. The contractor shall consider all these costs in the net unit rate under relevant items in the Schedule of Quantities.

The contractor shall give clear 15 days notice in writing for all such tests to be carried out at relevant place of Manufacture, Works, and Sub-works etc. The cost of incidental to such tests being carried out shall be borne by the Contractor and shall be deemed to have been included in the specific unit rate of that item.

11. GENERAL CONDITIONS OF SUPPLY OF EQUIPMENT

The Contractor shall submit all technical data and catalogues of all relevant manufactured goods he wishes to supply in his offer. However, the supply and selection of materials and makes shall comply with the standards and approvals set herein only. The list of approved materials and makes are listed separately under this Techno-Commercial Part. Wherever a choice of makes is indicated, it will be deemed that the engineer in charge shall have the right to select the equipment in the series of different choice of makes offered.

All tests to be performed prior to supply. It is generally expected that all type and routine tests for all, equipments required to be supplied under this tender shall complied.

12. SHIPPING, STORAGE, PROTECTION AND PROGRAM

The supplier shall be responsible for assuring that all equipments and materials shipped are properly packed and protected to prevent damage or deterioration during shipment. Packaging and shipping costs shall be borne by the contractor. Customs clearance and all costs and actions associated with import duties, taxes and processing of documents within India are borne by the contractor.

Each package of the consignment is to be marked indicated below:
Port of Shipment:
Port of destination:
Consignor:
Consignee:
Gross Weight:
Net Weight:
Shipping or Invoice reference number:
Shipping address:

The Contractor shall submit a schedule on procedure for inspection during installation so as to maintain quality control on the job site. The Contractor shall submit a detailed method statement for the protection of the surface of all systems/equipment/materials etc during delivery and erection, with description as to when the protection can be removed. The contractor shall submit weekly reports on the inspection of erection and installation as directed by the engineer in charge.

All materials delivered to site shall be stored in allocated spaces where the stored materials will not be exposed to rain water, moisture or damage and shall permit easy access to and handling of the materials. Materials shall be stored neatly and properly stacked. Factory made, on site fabricated structures, systems, components etc. shall be transported, handled and stored in a manner to preclude damage of any nature. Accessory materials, required for erection at the site shall be delivered to the site in labeled containers by the manufacturer.

13. INSURANCE

The Supplier should provide insurance coverage ex-factory until commissioning, and acceptance for replacement or repair of any part of the consignment due to damage or loss.

14. INSPECTION & ACCEPTANCE

The engineer in charge shall inspect the system. An inspection protocol shall be provided by the contractor and shall include physical and functional checks. Inspection and approval of delivery of the entire system to site is required.

Inspection will comprise a visual assessment and verification of the quantity and conformity of components of the system supplied. This will be performed in the presence of the engineer in charge, Verification that all packages are received in good condition and quantities correspond with Delivery Challan.

The contractor shall submit a detailed plan indicating the types of tests to be carried out by them.

Materials received at site and inspected after un-packing or while being installed found damaged or unsatisfactory shall be identified, properly tagged as unfit for use and removed from site as soon as possible to avoid any inadvertent usage of the same.

15. RATING AND NAMEPLATES

All the equipment shall be provided with rating and nameplate indicating the basic parameters, rating, serial number etc. The nameplate shall be of non - corrosive material and details shall be engraved. All the rating name plates should contain details as per the relevant I.S. Codes, wherever applicable.

16. TAKING OVER

After successful completion and all the tests conducted at site on the plant, equipment shall be handed over to engineer in charge.

17. PERFORMANCE

The contractor shall be fully and solely responsible for proper, safe and efficient design and performance of his equipment and installation, in conformity with drawings and parameters and specifications stipulated in the Contract documents.

In case the contractor finds that anything contained in drawings, specifications or given parameters will not ensure such performance and compliance with best trade practices and codes, rules and regulations laid down in the specifications, he shall bring such matters to the attention of the tendering authority before finalizing.

The Contractor shall guarantee that the performance of the various equipments individually and the same shall not be less than specified

ratings when working under operating conditions given for the respective items in the finally accepted "schedule of equipment."

18. COMPLETION DRAWINGS & ACCEPTANCE OF INSTALLATIONS

The Contractor shall submit the required guarantees for the works in approved formats as well as performance guarantees for those items of works for which such guarantees are required.

Before handing over the plant, 3 copies of operation and maintenance manual for major equipment shall be furnished to the employer along with 3 sets of " as built" drawings of all the works done as executed by the contractor.

In addition to hard copy of as built drawings, the contractor shall also supply a soft copy on a CD containing these drawings in a digital form (with Auto Cad & PDF Latest version). Similarly the operation and maintenance manual etc. shall also be supplied in a CD/CD’s with suitable indexing format for easy retrieval and reference.

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CHAPTER 2
SPLIT AIR-CONDITIONER

1. SCOPE:

The scope covers the technical requirements for supply, installation, testing at site including carrying out performance tests and commissioning into service of all-weather split type air cooled air conditioner with cooling & heating provision as per BOQ.

2. AMBIENT CONDITIONS:

The Air-conditioning and ventilation equipment are required to Operate under the following ambient conditions: -

Maximum temperature = 45° C
Minimum temperature = 5^0 C
Maximum Relative Humidity = 75%

3. CODES AND STANDARDS.

The Design, manufacture, inspection, testing and commissioning of the equipment covered in the specification shall confirm to the intent revision of the applicable codes and standard. Nothing in this specification shall be constructed to relieve vendor of his responsibility. In particular split type air cooled Air-conditioner shall confirm to the latest edition of the following standards: -

IS 660		Safety code for Refrigeration (revised)
IS 1391 (Part 2) : 1992		SPLIT AIR CONDITIONERS
IS 196 : 1966		Atmospheric conditions for testing
IS 302-1(1979)		Safety of household and similar electrical appliances : Part' 1 General requirements (filth revision)
IS 660 : 1963		Safety code for mechanical refrigeration
IS 694 : 1977		PVC insulated cables for working voltages up to and including 1 100 volts (second revision)
IS 996 : 1979		Single-phase small ac and universal electric motors (second revision)
IS 10617 (Part 1) : 1983		Hermetic compressors: Part 1 High temperature application
IS 10773 : 1983		Copper tubes for refrigeration purpose
IS 11338 : 1985		Thermostats for use in refrigerators, air conditioners, water coolers and beverage coolers
IS 5111		Code of practice & measurements procedures for testing refrigerant compressors.
IS: 1239		Mild steel tubes, tubular and other wrought steel pipe fittings.
IS: 210		Gray iron castings
ARI 495-61		Standard for refrigerant liquid receivers

ASHRAE 23-59		Standard method of testing for rating refrigerant compressors.
ASA-8-31.5		Code for refrigerant piping.

4. GENERAL DESCRIPTION OF SPLIT TYPE AIR CONDITIONERS (AIR COOLED)

This specification covers the design, manufacture, construction, fabrication, supply, delivery and installation of air cooled split air conditioner with both cooling and heating facility comprising indoor & outdoor units i.e. condensing and evaporating units. The outdoor / condensing units shall consist of hermetically sealed scroll / twin rotary compressor, condensing coil, condenser fan with motor, refrigerant inter connecting piping & reversing valves and safety interlocks etc all assembled in rigid cabinet with fixing arrangements. The indoor unit shall consist of evaporating coil, refrigerant expansion valve, Air blower with multiple speed motor, Air filter, motorized supply air grilles & return air grilles / slots, condensate drain pan and insulated drainage piping, electronic control circuit with cord less LCD remote controller sensor, power and control wiring etc, all assembled in a decorative type indoor unit with fixing arrangement.

The split air conditioner shall include the inter connecting refrigerant grade copper piping with insulation as per manufacturer's recommendation, suitable power supply cable to the indoor & outdoor units. The split AC indoor units shall operate on remote controller for all functional operations complete all as per SOQ and instruction of E-I-C. The capacity shall be as specified in schedule of quantities. The Department will provide only adequate single / three phase power point. All the other accessories items equipment's etc. whether specified or not shall deemed to be included in A/C agencies scope of work.

5. DESIGN EQUIPMENT

5.1 MATERIAL

The split type air-conditioner shall be constructed with the strength and adequate for normal conditions of handling, transport and usage. There shall not be any sharp edges corners, liable to cause injury, under normal conditions of use and all moving parts which constitute accident hazards shall be effectively guarded. The parts which required periodic servicing shall be readily accessible. Material used for outer cabinet, back panel etc, shall be of heavy gauge sheet steel. When sheet steel is used the same shall be finished with two coats of rust preventive paint and two coat of enameled powder coat paint. The sealing and insulating materials shall not lose their essential properties such as adhesive moisture and heat resistance.

5.2 INDOOR COOLING COIL & REFRIGANT PIPING:

The indoor unit shall consist of evaporating coil of heavy gauge copper with aluminium fins, refrigerant expansion valve shall be of capillary expansion tube / thermostatic expansion valve, Air blower with multiple

speed motor, Air filter, motorized supply air grilles & return air grilles / slots, condensate drain pan and insulated drainage piping, electronic control circuit with cord less LCD remote controller sensor, power and control wiring etc, all assembled in a decorative type ABS fire retardant enclosure with fixing arrangement. The refrigerant piping shall be of copper complete covered with adequate thermal insulations and protected by aluminum foil wrapping. The indoor unit shall provided with cord less LCD remote controller.

5.3 OUTDOOR UNIT:

The outdoor / condensing units shall consist of hermetically sealed scroll/ twin rotary compressor, condensing coil, condenser fan with motor, refrigerant inter connecting piping & reversing valves and safety interlocks etc all assembled in rigid cabinet with fixing arrangements. The condenser unit shall be air cooled type with propeller fan having Aluminum / Fiber / HDPVC Blades, Fresh air shall be drawn through side louvers and hot air discharged through condensing coil at the rear of the unit. The condenser shall be heavy gauge copper tube with Al. fins. The outdoor unit cabinet shall be of MS 22 G power coated for withstanding all weathers and shall be mounted on steel platform by agency in their scope of supply. The capacity of outdoor unit shall be not less than indoor unit.

5.4 AIR FILTERS

The filter medium shall be of fibrous materials (e.g. coir extruded sections of polythene etc.) packed into a frame. The fiber shall be bonded together suitably to prevent proving or loosening under normal operation.

5.5 COMPRESSOR

The refrigerant compressor shall be of hermetically sealed scroll/twin rotary suitable for Refrigerant R-410A or any other eco friendly CFC free gas. The compressor shall be mounted on rubber / spring type vibration isolators. The compressors shall have built-in vibration isolators. The Compressors shall have built-in over load relay and the motor shall be capacitor-start Capacitor-run type. Compressor shall be capable of operating continuously even at high Ambient temperature 48 C.

5.6 AIR HANDLING FANS

The air handling fans shall be of centrifugal type with forward curved blades and shall be complete with drive motor and drive. The motor shall be of minimum two speed type.

5.7 MISCELLANEOUS FEATURES

The grills & diffusers shall be easily removable for servicing the filters. The supply air grills shall be fully adjustable type with double deflection arrangement, so as to distribute the air into the room with sufficient throw and without drafts.

6. INSPECTION AND TESTING (GENERAL)

The contractor shall perform all tests and inspection necessary to ensure that the material and workmanship confirm to the requirements of the contract.

The contractor shall maintain records of all testing/inspection. A procedure for the repair of defects shall be submitted to the E-I-C for approval, prior to any repair being made. If the previous quality tests and inspection are impaired by the subsequent repairs, the work shall be re-inspected and re-tested to the satisfaction of the Purchase or his authorized representative. Equipment found unsatisfactory as to workmanship or materials shall be removed by the contractor and replaced to the satisfaction of the E-I-C at no extra cost.

Final acceptance will be given after the equipment is installed and tested at site to give satisfactory performance, as per IS standards.
The contractor shall provide, office facilities, necessary equipment and tooling instruments, drawings and personnel etc, required for proper inspection/testing of the work.

The contractor shall submit, the following documents before acceptance:-
1) All site test observations and calculation.
2) All the operation and maintenance manuals.
3) Leaflet and literature.
4) Test Certificate.

7. GUARANTEE:

The Manufacturer shall give guarantee for the soundness of construction and performance of the airconditoner, and shall be responsible for putting right any manufacturing defects free of charge for a minimum period of 12 months right from the date of acceptance by department. Such repairs or replacements of defective parts shall be carried out at Manufacturer's works free including consumables.

Noise level of split type airconditioners shall be relatively low not exceeding 55 db (on A scale) and free from high pitched and metallic noises. To avoid rattles and vibration in the building structure, the units shall be correctly installed.

8.0 REFRIGERANT PIPING

Refrigerant piping shall be designed to ensure the following:
a) To ensure proper feed of liquid to evaporator.
b) Sizing of refrigerant piping without excessive pressure drop.
c) To protect compressor by preventing excessive lubrication oil from trapped in the system.
d) To protect compressor by preventing liquid refrigerant from entering the compressor during the operation & shut down.
e) Refrigerant piping shall be tested for leaks with leak detector.

Refrigerant piping shall be made of copper tubing. Refrigerant piping shall be in Accordance with safety code for mechanical refrigerant of ANSI standards. The refrigeration piping shall be complete with the necessary fittings and valves. Check valve on the discharge line.

9. TEST RESULTS CAPACITY COMPUTATIONS:

SNo.	Item	Test Results
1	Ambient conditions readings	DB temp. ° C WB Temp ° C R.H.
3	Compressor Motor	Voltage & Current at100% load in Amps
4	Condensers (For both heating and cooling)	Air flow rate FPM Air temperature entering(° C) Air temperature leaving(°C)
5	Evaporator (For both heating and cooling)	Total air flow rate across Coil Air entering temperature DB (° C) & WB(° C) Air leaving temperature DB (° C) & WB(° C)
6	Room condition at working place(For both Summer and winter)	Temperature DB (° C) Temperature WB (° C)
7	Controls	Function of each control shall be tested and report furnished.
8	NOTES : 1) All instruments shall be provided by air-conditioning vendor. 2) All thermometers for refrigerant measurement shall have graduations of 0.1 ° C & shall be collaborated from a recognized test house. 3) Pressure gauges shall be calibrated as under (2) above. 0.2 graduations.	

10. DRAIN PIPING DULY INSULATED:

Supply, installation and commissioning of rigid / flexible HD PVC piping duly insulated with closed cell elastomeric nitrile rubber insulation as per instructions of Engineer-in-Charge.

11. ALUMINIUM CLADDING:

Suppling and wrapping of 26 Guage Aluminium cladding for exposed piping to protect it from physical damage, environment as required as per site situation and Engineer-in-Charge.

12. M S STAND FOR ODU OF SPLIT AC:

Fabrication, supply & installation of M.S. stand for the ODU (outdoor unit) of A/C unit as required fabricated out of M.S. flat of size (50 mm x 8 mm) and M.S. angle of size (50 mm x 50 mm x 8 mm) and safety guard of M.S. flat of size (12 mm x 12 mm) with front gate having suitable opening for taking out the ODU for maintenance purpose of ODU unit, painting with two coats of synthetic enamel painting over one coat of red oxide primer of approved make & shade to all M.S. parts at all levels & elevations as required.

13. GALVANIZED TRAY:

Supply & fixing of ladder type GI cable trays sizes for laying refrigerant pipes as mentioned in SOQ with vertical sides on both ends and suitable MS supports with vertical sides on both ends and suitable MS supports including concrete bolts, hold fast etc. The scope includes supply of readymade bends, reducers, Tee, covers etc. as required.

14. GI SHEET COVER:

Supply, installation and fabrication of 22 SWG GI sheet over and above the refrigerant piping laid down on terrace with easy removal facility as per clause no. 10 of technical specifications and instructions of Engineer-in-Charge.

15. PCC SUPPORTS:

Providing PCC pedestals / thrust / anchor block of required sizes for refrigerant pipes, outdoor units etc. and specials with cement concrete 1:2:4 at required intervals including form work, curing, finishing etc. completed in all respect.

16. AIR CURTAINS

Air Curtains with photo sensor (of medium velocity) providing 150-200 fpm at the floor level to stop the entry of unintended ambient air in the air conditioned area. Body material should be of GI Powder Coated. The Air curtains shall be installed for the Entry doors . These air curtains shall be suitable for doors of height 2.1 meters. The body of the Air Curtains shall be MS powder coated. The necessary cabling and PVC trunking for the Air Curtains shall be provided as per the SOQ.

CHAPTER 3
TECHNICAL DATA TO BE FURNISHED ALONG WITH TENDER

TECHNICAL BID

1. Split AC

Sr.No.	Parameters		To be filled by tenderer
1.	Capacity of Split AC unit		
2.	Name of the manufacturer		
3.	Cooling Capacity in TR		
4.	Heating Capacity in BTU/hr		
5.	Outdoor unit Dimension (mm) H X W X D		
6.	Outdoor unit Overall wt of Unit (Kg)		
7.	Outdoor unit Noise level (db) of the unit at 1.0 M distance horizontally in front of the unit at scale “A & C”		
8.	Power supply required for outdoor unit in KW		
9.	Indoor unit Dimension (mm) H X W X D		
10.	Indoor unit Overall wt of Unit (Kg)		
11.	Indoor unit Noise level (db) of the unit at 1.0 M distance horizontally in front of the unit at scale “A & C”		
12.	Power supply required for Indoor unit in KW		
13.	Name of Refrigerant used		
14.	Warranty		
15.	Star rating		

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Part 4
Technical Specifications for Ventilation System

CHAPTER 1
KITCHEN VENTILATION

1) SCOPE

The scope of this clause covers the supply, installation, testing & commissioning of kitchen ventilation system as specified in the drawings and in accordance with the requirement of the Schedule of Quantities.

2) DESIGN REQUIREMENT

2.1 Wall mounted propeller exhaust fans, a fresh air supply system and an exhaust system shall be provided by using high pressure inline fans, Heavy gauge S.S hood with air balancing G.I. dampers, G.I. ducting, five layer removable / washable grease collection wire mesh ferrule filters in S.S. or Aluminium construction to get min. 25-30 air changes per hour i.e. entire indoor polluted air (mixture of oil, steam, smoke and grease etc.) shall be filtered in grease collecting hood and exhausted out from the kitchen area all as per S.O.Q., drawing & standard practices. The hood & system shall be designed for a total static pressure of 40 mm WG. The total amount of exhausted air will be replaced by fresh air.

2.2 CODES & STANDARDS

The Design, Manufacturing & Performance of kitchen hood & fan shall comply with all currently applicable statutes, regulations & safety codes in the locality where equipment shall also conform to the latest editions of applicable I.S. & B.S.

2.3 MATERIAL & WORKMANSHIP

All material used must conform with applicable standards & codes must be new & free from objectionable imperfections & shall be fabricated in a workman like manner. Contractor shall properly select the material to the best standard followed in the industry for particular application, subject to the approval of Engineer in Charge.

2.4 GENERAL REQUIREMENT

The kitchen hood, propeller fan and inline fans shall be factory built to industry's highest standard to ensure maximum mechanical & electrical reliability. The fan equipment shall be suitable to operate for quiet, stable & less vibration at air flow specified.

2.5 KITCHEN HOOD

Kitchen hoods shall be made out of 18 SWG S.S. sheets as per S.O.Q. & drawing, the connecting ducting shall be as per sheet metal (duct work) standards and exhaust air ducting shall be out of 20 gauge G.I. sheets. The kitchen hood shall be adequately supported from the ceiling or from the floor as per the drawing.

2.6 AIR VELOCITIES

Air Velocities in ducts for shall not exceed the following:

a)	Main Ducts	1500	feet per minute
b)	Branch ducts	1200	feet per minute
c)	Diffusers	600	feet per minute
d)	Across hood filters	250	feet per minute
e)	Outside air intakes	1000	feet per minute
f)	Fan outlet	2000	feet per minute
g)	Capture Velocity	50-100	feet per minute

2.7 Sheet Metal Works shall be as per relevant section and clause of this document.

3) FANS

3.1 GENERAL REQUIREMENT

The unit shall be factory built to industry's highest standard to ensure maximum mechanical & electrical reliability, the fan equipment shall be suitable for quiet, stable & vibration less operation at airflow specified.

3.2 TYPE & CAPACITY

Inline and propeller fans shall be of the type and capacity as indicated on Drawings and identified in Schedule of Quantities.

3.3 MATERIAL & WORKMANSHIP

All material used must conform with applicable standards & codes, must be new & first class in all respect. Parts shall be free from flaws & objectionable imperfection & shall be machined in a true workman like manner. Contractor shall properly select the material to the best standard followed in the industry for particular application, subject to the approval of Engineer in Charge.

3.4 CODES & STANDARDS

The design, manufacturing & performance of fan shall comply with all currently applicable statutes, regulations & safety codes in the locality where equipment shall also confirm to the latest editions of applicable Indian standards. Nothing in this specification shall be construed to relieve the contractor of his responsibilities.

3.5 WALL MOUNTED PROPELLER EXHAUST FANS

Propeller fans shall be directly driven by a squirrel cage induction motor. Fan shall be of heavy industrial design and the AMCA standard of engineering & manufacture shall be fully met. Impeller shall have fixed blades. It should be possible to substitute the impeller with new one without substantially lowering the efficiency of the fan.

Impeller blades shall be of aerofoil section & shall be of good quality cast aluminium. The impeller shall be accurately balanced both statically & dynamically. The critical speed shall be at least 1.25 times the operating speed. Fan frame/casing shall be constructed from mild steel. When galvanized casing are specified, all screws, nuts & bolts shall be galvanized as per IS: 2629. Scope includes required cabling from SFU to starter & motor of fan.

3.6 INLINE FANS (FOR SUPPLY & EXHAUST)

a) SCOPE:

The scope includes supply, installation, testing and commissioning of heavy duty, continuously rating, frame mounted inline supply & exhaust fans. The impellers should be CRCA MS material, cowls shall be as per tender drawings & SOQ. Installation of the frame on brick wall or on openings of suitable sizes shall be in bidder scope.

Any wooden frames for the fans if required shall be included in the bidder scope. The contractor shall install the fans on these wooden frames using adequate size galvanized nut bolt and washers and mounting arrangements with vibration eliminators shall be included in scope of the bidder.

The cowls and birds screen shall be mounted directly on wall/window frames on the other side of the fans using galvanized nut bolt arrangements. A safety metal string or chain shall be provided to the fan to safeguard accidental falling.

The multi stranded copper power cable of adequate size & length shall be included in the bidders scope from the fans' to power socket with tinned copper earthing etc shall be provided in line level.

The fan motor shall be TEFC type and suitable for operating on 415V, 3 phase, 50Hz AC supply. The cost shall include the price of the steel supports required for mounting the fan and bird screen, wire mesh and storm proof louvers as required. The scope shall include outdoor rated starter panel (IP 55 rating) with DOL starter of required capacity, incoming cable connections, SFU, overload relays, ON / OFF push buttons, indicating lamps (ON/OFF trip), sufficient length of armoured power cable with earthing from starter panel to motor all complete in all respects for putting the fan into operation.

b) EARTHING:

Each fan shall be provided with a earthing terminal and all the metal or metal enclosed parts of the unit shall be connected to earth terminal by cable socket so as to ensure satisfactory earthing continuity.

c) LABELLING

The complete fan together with all components shall be properly labelled to indicate manufacturer's name type of model operating voltage, current frequency, power consumption, speed and any other relevant date for identification.

d) BIRD SCREEN & COWL

The cowl shall be fabricated out of 22 SWG G.I. sheet and bird screen of stainless steel not more than 1mm square.

e) TESTING

The following tests shall be conducted as per the relevant I.S at manufacturers Work, test reports or the same shall be submitted along with the supply.

f) TYPE TEST

The manufacturer shall carry out the type test on sample selected at random from each type of the fan or furnish test certificate to establish compliance with the requirements.

g) ROUTINE TEST

The manufacturer shall carry out the following routine test on sample selected as per I.S. at random from each type of fan offered and furnish test certificate to establish compliance with desired requirements.

h) VISUAL CHECK

Each fan be examined visually to ensure that it is complete in all respects and satisfactorily finished.

i) TESTING OF EXHAUST FANS

The fans shall be tested after installation in presence of departmental engineer and following tests results shall be furnished.

- Capacity test (CMH)
- Static pressure at the fan inlet and discharge side.
- Noise level/vibration.
- Current consumption of fan motor.

j) GUARANTEE

The fans shall be guaranteed for satisfactory operation for 12 months from the date of commissioning and handing over. During the guarantee period if any defects noticed or observed same shall be repaired/replaced free of cost. All fans shall have I.S. mark (I.S. No. 2312/1967) and provided with class ‘F’ insulation, ISI marked motors of single phase and 3 phase respectively.

k) PAINTING

The fans shall be epoxy coated in two layer after duly surface treatment and two coats of primer, the shade of epoxy shall be aircraft gray.

4) INSTALLATION

The M.S. / RCC foundation or support required for installing the fans shall be included in the scope of Bidder along with all accessories i.e. foundation bolts, base plate, spring type vibration eliminator etc. as per the drawing & S.O.Q. He shall also ensure that all the above accessories are placed securely by him in proper position & in good time while the foundation is cast. Fan inlet / outlet connections shall be by means of

suitable PVC/FRP flexible material. Fan belt drive shall be complete with belts sheaves & suitable belt guard.

The unit shall be painted with Anti corrosive Epoxy paint & enamel paint or equivalent with the following procedure:

The bare metal should be cleaned thoroughly by standard procedure & one coat of red oxide chromate primer should be applied within four hours of cleaning. The primer should be allowed to dry thoroughly before the application of first coat of paint. The paint should be applied in 3 coats with coverage of minimum 6 to 7 sq. meter/Litre/coat.

Contractor shall take due care while installation, that no vibration are being transmitted to be building, structures etc. Suitable flexible connections of PVC also shall be provided. Until shall be painted with approved colour in two coats after testing of the fan.

5) PERFORMANCE DATA

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

6) TESTING OF FANS

Fans shall be tested at manufacturer's works for the following tests in the presence of the Engineer in Charge and to his satisfaction & test results shall be furnished;

(1) Capacity test (CHM)
(2) Static pressure at the fan inlet & discharge side
(3) Noise level / vibration
(4) Current consumption of fan motor.

After installation at site the fans shall be subject to the above tests again to the Engineer in Charge's satisfaction.

7) DEFECT LIABILITY PERIOD & GUARANTEE:

The complete system shall be guaranteed for a minimum period of 12 months from the date of taking over by the department against any faulty materials. Any fault or defect occurring during the said guarantee period will be attended to by the contractor (including design, material, labour, transport supervision etc.) on priority basis & free of cost to the department.

In case the contractor fails to do so the department shall have a right to get it done by other agencies at risk & cost of the contractor without affecting guarantee clause.

8) NOISE AND VIBRATION

Noise level produced by any rotating equipment individually or collectively shall not exceed 65 dB (A) measured at a distance of 1.5 meters from the source in any direction. The overall vibration level shall be as per zones A and B of ISO 10816-1. Balance quality requirement shall be of grade G 6.3 conforming to ISO 1940/1.

9) FILTER BANK

Fabrication and supply of M.S filter bank along with 4 Ply HDPE Pre-filters (6 Nos.) of size 610 mm x 610 mm x 305 mm, filter frame fabricated out of MS Angle/Channel/I-Section for housing Pre-filters. The filter bank casing shall be fabricated out of 3 mm thick M.S Sheet. The HDPE pre filter casing shall be 16 G thick G.I sheet. The efficiency of these filters shall be 90% down to 10 micron particle size. These filters shall be tested at manufacturer's works as per ASHRAE 52.1 & 52.2 standards i.e for both gravimetry as well as opacity method.

10) TECHNICAL INFORMATION TO BE SUBMITTED BY THE BIDDER ALONG WITH TENDER:

A) Kitchen Hoods

i) Material of Kitchen hoods.

ii) Overall dimensions of each kitchen hoods with their weights.

iii) Make of material

iv) Mounting details of Kitchen hoods

B) Filter Details

a) Type of filters with construction details

b) Material thickness

c) Filter dimensions

d) Filter mounting arrangements

e) Cleaning procedures

f) Nos. of layers

g) No. of filters

C) Oil collecting provisions

i) Dimension of oil collecting trays and material

ii) Thickness of tray

iii) Oil collecting cock

D) G.I. Ducting

i) Make of G.I. Sheets

ii) Type of dampers with thickness & material

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CHAPTER 2
TOILET & ELECTRICAL ROOM VENTILATION

1) SCOPE

The scope of this clause comprises the supply, installation, testing and commissioning of toilet & electrical room ventilation system comprising of wall mounted propeller exhaust fans & inline fans along with required ducting, conforming to these Specifications and in accordance with the Drawings and requirement of Schedule of Quantities.

2) TYPE & CAPACITY

Propeller type & inline type fans shall be of capacities as indicated on drawings and identified in Schedule of Quantities.

3) DESIGN REQUIREMENT

Toilet ventilation and Electrical room system shall consist of wall mounted propeller exhaust fans & inline fans with ducting & grilles wherever required. Wherever ducting is required for toilet exhaust, the exhaust duct shall be provided with goose necking as shown in drawings. The cost shall include the price of the steel supports required for mounting the fan and S.S bird screen, wire mesh and storm proof louvers as required. The fan shall have min ESP of 25 mmWC.

4) AIR CHANGES PER HOUR

Toilets shall be provided with ventilation of 6-10 ACPH. Electrical rooms shall be provided with ventilation of 10-15 ACPH.

5) MATERIAL & WORKMANSHIP

All material used must confirm with applicable standards & codes must be new & free from objectionable imperfections & shall be fabricated in a workman like manner. Contractor shall properly select the material to the best standard followed in the industry for particular application, subject to the approval of Engineer in Charge. The Sheet Metal Works shall be as per relevant section and clause of this document.

6) FANS

6.1 TYPE & CAPACITY

Inline and propeller fans shall be of the type and capacity as indicated on Drawings and identified in Schedule of Quantities.

6.2 CODES & STANDARDS

The design, manufacturing & performance of fan shall comply with all currently applicable statutes, regulations & safety codes in the locality where equipment shall also confirm to the latest editions of applicable Indian standards. Nothing in this specification shall be construed to relieve the contractor of his responsibilities.

6.3 MATERIAL & WORKMANSHIP

All material used must confirm with applicable standards & codes must be new & first class in all respect parts shall be free from flows & objectionable imperfection & shall be machined true in a workman like manner. Contractor shall properly select the material to the best standard followed in the industry for particular application, subject to the approval of Engineer in Charge.

6.4 GENERAL REQUIREMENT

The unit shall be factory built to industries highest standard to ensure maximum mechanical & electrical reliability, the fan equipment shall be suitable for quiet, stable & vibration less operation at airflow specified.

6.5 WALL MOUNTED PROPELLER EXHAUST FANS

Propeller fans shall be directly driven by a squirrel cage induction motor. Fan shall be of heavy industrial design and the AMCA standard of engineering & manufacture shall be fully met. Impeller shall have fixed blades. It should be possible to substitute the impeller with new one without substantially lowering the efficiency of the fan.
Impeller blades shall be of aerofoil section & shall be of good quality cast aluminium. The impeller shall be accurately balanced both statically & dynamically. The critical speed shall be at least 1.25 times the operating speed. Fan frame/casing & components shall be constructed from mild steel. When galvanized casing are specified, all screws, nuts & bolts shall be galvanized as per IS: 2629. Scope includes required cabling from SFU to starter & motor of fan.

6.1 INLINE EXHAUST FANS

Inline fans shall be direct driven or belt driven, of noiseless operation. The fan motor shall be suitable for operating on 230V, 1 phase, 50Hz AC supply. The fans shall be suitable for outdoor application along with motors flexible connections, vibration isolators. The body shall be made of impact resistant ABS plastic / good quality cast aluminium / galvanised iron / mild steel. The casing shall be air tight and have non return damper to prevent back flow and spigot damper for flexible duct connections. The cost shall include the price of the steel supports required for mounting the fan and bird screen, wire mesh and storm proof louvers as required. The scope shall include outdoor rated starter panel (IP 55 rating) with DOL starter of required capacity, incoming cable connections, SFU, overload relays, ON / OFF push buttons, indicating lamps (ON/OFF trip), sufficient length of armoured power cable with earthing from starter panel to motor all complete in all respects for putting the fan into operation. The fan shall have min ESP of 25 mm WC.

7) INSTALLATION

The M.S. supports required for fans shall be included in the scope of Bidder along with all accessories like bolts etc. as per the drawing & S.O.Q. Contractor shall take due care while installation that no vibration are being transmitted to be walls. Suitable flexible connections of PVC also shall be provided.

8) PERFORMANCE DATA

All fans shall be selected for the lowest operating noise level. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation.

9) TESTING OF FANS

Fans shall be tested at manufacturer's works for the following tests in the presence of the Engineer in Charge and to his satisfaction & test results shall be furnished;

(5) Capacity test (CHM)
(6) Static pressure at the fan inlet & discharge side

(7) Noise level / vibration
(8) Current consumption of fan motor.

After installation at site the fans shall be subject to the above tests again to the Engineer in Charge's satisfaction.

10) DEFECT LIABILITY PERIOD & GUARANTEE:

The complete system shall be guaranteed for a minimum period of 12 months from the date of taking over by the department against any faulty materials. Any fault or defect occurring during the said guarantee period will be attended to by the contractor (including design, material, labour, transport supervision etc.) on priority basis & free of cost to the department.

In case the contractor fails to do so the department shall have a right to get it done by other agencies at risk & cost of the contractor without affecting guarantee clause.

11) NOISE AND VIBRATION

Noise level produced by any rotating equipment individually or collectively shall not exceed 65 dB (A) measured at a distance of 1.5 meters from the source in any direction. The overall vibration level shall be as per zones A and B of ISO 10816-1. Balance quality requirement shall be G 6.3 conforming to ISO 1940/1.

12) TECHNICAL INFORMATION TO BE SUBMITTED BY THE BIDDER ALONG WITH TENDER:

A) G.I. Ducting

i) Make of G.I. Sheets.

ii) Type of dampers with thickness & material.

Part 5
MODE OF MEASUREMENT, TESTING & COMMIOSSIONING

CHAPTER 1
MODE OF MEASUREMENT

For variable items like sheet metal ducting, insulation, piping works, cabling etc., the following measurement procedure shall be adopted for billing purposes.

1. DUCTING

Unless otherwise specified, measurements for ducting shall be on the basis of centre-line measurements described herewith:

- Duct Work shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the centre of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in similar manner.
- For tapered rectangular ducts, the average width and depth shall be considered for perimeter. The length of tapered duct section shall be the centre line distance between the flanges of the duct section.
- For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centre line.
- The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 4 mm thick between duct and support, vibration isolator, suspension where specified or required, inspection chamber / access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the Specifications. These accessories shall NOT be separately measured nor paid for.
- Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith:
- Grilles - width multiplied by height, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
- Diffusers - shall be measured by cross-sectional areas at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
- Linear diffusers - shall be measured by cross-sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.

2. DUCT INSULATION

The measurements for insulation of ducts shall be made in actual square metres of bare uninsulated duct surface through all dampers, flanges and fittings. In case of bends the area shall be worked out by taking an average of inner and outer lengths

of the bends. Measurements for the dampers, flanges, fittings shall be measured for the surface dimension. The overlapping of insulation shall not be measured separately for billing purpose. In case of acoustic lining of air ducts, measurements of the bare inside duct surface in square meters, shall be final for billing purposes. The acoustic insulation of plenum boxes shall not measured separately as it is part of plenum box supply as specified in Specification / SOQ. The insulation/acoustic panels shall include cost of battens, supports, adhesives, vapour proofing, finished tiles/boards sheets as well as additional labour and material required for completing the work.

3. CHILLED WATER PIPING, HOT WATER PIPING & DRAIN PIPING

Unless specified otherwise, measurement for piping shall be on the basis of centre line measurements described herewith.

Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted.

The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately measured nor paid for.

However, all valves (gate / globe / check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications / SOQ description.

All the extra CI & CM flanged valves shall be measured according to the nominal size in mm and shall be measured by number. Such valves shall not be counted as part of pipe length hence deduction in pipe length will be made wherever valves occur. All valves shall include two Nos. of flanges and two numbers of 150 mm long MS nipples, with one side threaded matching one of the valves, and other welded to the M.S. slip-on-flange. Rate shall also include the necessary number of bolts, nuts and washers, 3 mm thick insertion gasket of required temp. grade and all items specified in the specifications.

The rates quoted shall be inclusive of making connections to the equipment, tanks, pumps etc. and the connection made with an installed pipe line shall be included in the rates as per the SOQ. Contractor shall get pressure testing of pipes / measurements etc verified by the Engineer in Charge at site.

4. PIPE INSULATION

Unless otherwise specified measurement for duct and pipe insulation for the project shall be on the basis of centre line measurements described herewith. Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly

on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

5. ACCESSORIES INSULATION

The insulation for accessories such as expansion tank, pumps, valves, etc. shall be considered in the respective items and hence shall not be measured separately.

6. CABLING

Payment for Cabling works shall be effected on the basis of linear measurement measure from gland to gland. Any looping provided in cables near to the terminations shall also be measured and paid for. However, such looping shall not exceed 2 RMT per termination. No payment shall be made for left out and installed cut cable pieces. The rates quoted for underground cable laying shall include excavation charges, sand cushioning, standard burned brick protection, refilling, consolidating etc. The rates for cable termination works shall include the costs of copper / aluminium termination sockets of suitable type, brass single compression cable glands, copper earth clamps for glands, taping, crimping, yellow pasting, all labour charges etc., The payment for cable trays shall be effected based on the linear measurement of the cable trays of different sizes. The cost shall be inclusive of basic cable tray, suspenders and labour for tray fitting, fabrication and erection.

7. STRUCTURAL SUPPORTS

Structural supports like rods, clamps, bolts & nuts, etc for pipes and ducts shall be considered as part of pipe and ducts hence no separate payment will be made. Rates shall be inclusive of hoisting, cutting, jointing, welding, cutting of holes and chases in walls, slabs or floors, painting supports and other items as described in specifications, drawings and schedule of quantities or as required at site by Engineer in Charge. The MS supports like plate, channels, angles, etc shall be measured separately as described in SOQ

CHAPTER 2
TESTING AND COMMISSIONING

1. SCOPE

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

- Tests of all Equipment and Components at manufacturer's works as directed by the Engineer in Charge to his satisfaction.
- Perform site tests and commissioning as directed by the Engineer in Charge to his satisfaction.

2. SUBMITTALS

- For inspection and testing, submit inspection and testing procedures, programme, and record sheets applicable at each hold point.
- After completion of testing, submit test records, packaging, transportation and storage instructions and methods.
- For site installation and commissioning, submit installation methods or procedures, notification and procedures for pre-commissioning and commissioning.
- After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

3. INSPECTION AND TESTING

The contractor shall carry out all performance tests at the factory of the manufacturer and in the presence of the Engineer in Charge in a method approved by the Engineer in Charge and to his satisfaction and again upon supply and installation at site. All such performance tests carried out shall be recorded and submitted for approval to the Engineer in Charge.

The tests shall be performed to indicate freedom from vibration, unbalance, leakage and to establish the designed performance of the equipment. The contractor shall submit the procedure for site tests to Engineer in Charge for approval before commencing with the tests.

After the complete installation of air-conditioning System with ductwork, pipe-work with accessories installed, insulation etc. is completed, these shall be tested as per the applicable codes (unless otherwise specified) to check and assess the functional performance. These tests to be conducted at site in the presence of the Engineer in Charge, shall include, but not limited to the following equipment in summer, monsoon and in winter seasons.

Water Pumps factory inspection and test as per IS, BS & relevant standards.

- Visual inspection.
- Pump MOC inspection and testing.
- Designed capacity test (discharge and head).

- Motor insulation test.
- R.P.M. of Pumps.
- Vibration and Noise level
- Starting current and running current test.

Pipes and valves factory inspection and test as per IS, BS & relevant standards.

- Visual inspection.
- MOC inspection and testing.
- Designed Pressure tests.

Thermal and acoustic Insulations factory inspection and test as per IS, BS & relevant standards.

- Visual inspection.
- MOC inspection and testing.
- Designed thermal resistivity.

4. TESTS AT MANUFACTURER'S WORKS

- All tests to be performed during manufacture, fabrication and inspection shall be agreed with the Engineer in Charge prior to commencement of the work. The Contractor shall prepare the details of the schedule and submit these to the Engineer in Charge for approval. It must be ensured that adequate relevant information on the design code/standard employed, the manufacture/fabrication/assembly procedure and the attendant quality control steps proposed are made available to the Engineer in Charge who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections.
- A minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Engineer in Charge by the Contractor (whether the tests be held at the Contractor's of Sub-contractor's works). The subject items should remain available for the inspection by the Engineer in Charge and test up to a minimum 10 days beyond the agreed date of witnessing the test. Every facility in respect of access, drawings, instruments and manpower shall be provided by the Contractor and sub-contractor to enable the Engineer in Charge to carry out the necessary inspection and testing of the equipment.
- No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, all tests called for have been successfully carried out in the presence of the Engineer in Charge or approved for shipment by him or alternatively inspection has been waived.
- Functional, electrical, mechanical and hydraulic tests shall be carried out on completed assemblies in the works. The extent of these tests and method of recording the results shall be submitted to and agreed by the Engineer in Charge in sufficient time to enable the tests to be satisfactorily witnesses, or if necessary for any changes required to the proposed programme of tests to be agreed.

- The Engineer in Charge reserves the right to visit the Manufacturer's works at any reasonable time during fabrication of equipment and to familiarize himself with the progress made and the quantity of the work done to date.
- Within 30 days of completion of any tests, triplicate sets of all principal test records, test certificates and correction and performance curves shall be supplied to the Engineer in Charge.
- These test records, certificates and performance curves shall be supplied for all tests whether or not they have been witnessed by the Engineer in Charge or not. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title.
- When all equipment has been tested, the test certificates from all works and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index and four copies of each volume shall be supplied to Engineer in Charge.

5. PERFORMANCE TESTS AT MANUFACTURER'S WOKS

- All equipment may be subjected to routine performance tests at the Manufacturer's Works in accordance with the relevant ANSI, ASME, ASTM, BIS standard including operating tests of complete assemblies to ensure correct operation of apparatus and components.
- Pumps, fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% overspeed for 5 min to check vibration. Main and auxiliary gear boxes shall be subjected to shock load tests and a six-hour endurance run at rated speed and maximum torque.
- The Contractor shall submit single line diagrams including the layout of the equipment together with the location of test instrumentation and the principal dimensions of the layout. All calculations to derive performance data shall be made strictly in accordance with format given in the approved standards. Any alterations or deviations from the approved standard test layout or formulae shall be subjected to the prior approval of the Engineer in Charge.
- The performance test shall be conducted over the full operating range of the pump to a closed valve condition and a minimum of five measurement points covering the full range shall be taken. Curves indicating Quality vs. Head, Quantity vs. Power absorbed, and Quantity vs. Pump efficiency shall be provided. In addition a curve of the NPSH required vs. Quantity shall be provided except when the suction conditions do not require this test. Any proposal for the omission of this test shall be to the approval of the Engineer in Charge.
- On completion of the tests the Contractor shall submit a report showing the test results obtained together with the curves corrected to the site operating conditions.

TESTING, ADJUSTING AND BALANCING

1. SCOPE

- Testing, adjusting and balancing of heating, ventilating and air-conditioning systems at site.
- Testing, adjusting and balancing of HVAC Hydronic system at site.
- Testing, adjusting and balancing of exhaust system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : HVAC Application.
SMACNA : Manual for the Balancing and Adjustment of air distribution system.

2. PERFORMANCE

- Verify design conformity.
- Establish fluid flow rates, volumes and operating pressures.
- Take electrical power readings for each motor.
- Establish operating sound and vibration levels.
- Adjust and balance to design parameters.
- Record and report results as per the formats specified.

3. DEFINITIONS

- Test : To determine qualitative & quantitative performance of all equipment.
- Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)
- Balance : To proportion within distribution system (sub mains, branches and terminals) in accordance with design quantities.

4. TESTING, ADJUSTING AND BALANCING (TAB) PROCEDURES

The following procedures shall be directly followed in TAB of the total system. Before commencement of each one of the TAB procedure explained hereunder, the contractor shall intimate the Engineer in Charge about his readiness to conduct the TAB procedures in the format given in these specifications.

5. DESCRIPTION OF SYSTEM AND REQUIREMENTS

Adjust and balance the following systems to provide most energy efficient operation compatible with selected operating conditions.

- All supply, return and outside air systems.
- All exhaust air systems.
- All chilled water and hot water systems.
- Emergency purge systems.

6. AIR SYSTEMS

Air Handlers Performance

The TAB procedure shall establish the right selection and performance of the AHUs with the following results:

- Air-IN DB and WB temperature.
- Air-OUT DB and WB temperature.
- Dew point air leaving.
- Sensible heat flow.
- Latent heat flow.
- Sensible heat factor.
- Fan air volume.
- Fan air outlet velocity.
- Fan static pressure.
- Fan power consumption.
- Fan speed.

Air distribution

Both supply and return air distribution for each AHU and for areas served by the AHU shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers (Air Flow Hood with type)

The Preparatory Work

To conduct the above test, following preparatory works are required to be carried out including the availability of approved for construction shop drawings and submittals:

- All outside air intake return air and exhaust air dampers are in proper position.

- All system volume dampers and fire dampers are in full open position.
- All access doors are installed & are air tight.
- Grilles are installed & dampers are fully open.
- Provision and accessibility of usage of TAB instruments for traverse measurements are available.
- All windows, doors are in position.
- Duct system is of proper construction and is equipped with turning vanes and joints are sealed.

7. HYDRONIC SYSTEM BALANCING

- The Hydronic system shall involve the checking and balancing of all water pumps, piping network (main & branches), the heat exchange equipment like cooling and heating coils in order to provide design water flows.
- The essential preparation work, must be done by the HVAC contractor prior to actual testing, adjusting and balancing of HVAC system and ensure following :
    - Availability of co-ordinated drawings and approved submittals and system sketch with design water flows specified thereon.
    - Hydronic system is free of leaks, is hydrostatically tested and is thoroughly cleaned, flushed and refilled.
    - Hydronic system is vented.
- The contractor or his nominated TAB (Testing, Adjusting & Balancing) contractor shall confirm completion of the basic procedures and prepare check lists for readiness of system balance.

- Check pumps operation for proper rotation and motor current drawn etc.
- Confirm that provisions for TAB measurements (Temperature, pressure and flow measurements) have been made.
- Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for chilled water system and hot water system shall be carried out in a professional manner and test reports in the specified format shall be prepared and presented to the Engineer in Charge for approval.

8. READINESS FOR COMMENCEMENT OF TAB

Before starting of any of the tests, the readiness to do so should be expressly informed to the Engineer in Charge and the same must be recorded as per the prescribed check list.

9. TAB INSTRUMENTS

Instruments which shall be used for testing, adjusting and balancing shall comprise of but not limited to the following;

- Air Measuring Instruments
    - For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make VelociCalc Plus Meter, Model 8386, or equivalent shall be used. This instrument shall be capable of calculating the sensible, latent total heat flows, sensible heat factor and give printouts at site and have data logging/downloading facility.
    - For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
    - Pitot tube.
    - Electronic Rotary Vane Anemometer TSI make or equivalent.
    - Accubalance Flow Measuring Hood TSI make or equivalent.
    - All above instruments shall have NIST testification (US Institute of Science and Technology) Calibration Certificate
- Hydronic Measuring Instruments - For measurement of water flow, differential pressure and temperature, CBI Measuring instrument (Tour & Anderson AB Sweden or equivalent) shall be used. The instrument shall have a built-in microcomputer capable of giving readings for pressure differential, flow rate and temperature.
- Rotation Measuring Instrument - Electronic Digital Tachometer.
- Temperature & RH Measuring Instrument - TSI VelociCalc model 8386 and VelociCalc model 8345 or equivalent.
- Electrical Measuring Devices - Clamp on Volt ammeter & Continuity Meter.

10. IBRATION AND NOISE LEVELS

Vibration and alignment field measurements shall be taken for each circulating water pump, air handling unit and fan driven by a motor over 10 HP. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, and other test as directed by the Engineer in Charge. Sound level readings shall be taken at ten (10)

locations in the building as selected by the Engineer in Charge. The readings shall be taken on an Octave Band Analyzer in a manner acceptable to him. The contractor shall submit test equipment data and reporting forms for review. In order to reduce the ambient noise level the readings shall be taken at night. All tests shall be performed in the presence of Engineer in Charge.

ANNEXURE 1

LIST OF PREFERRED MAKES OF EQUIPMENT / MATERIAL

Materials / Equipment	**Manufacturer / Make**
Chilled water pumps	ITT / Grundfos / Armstrong /KSB/Wilo
Air Handling Units	Systemair / Caryaire / Citizen / Flaktwoods/Zeco
AHU Fans	Kruger / Nicotra / Greenheck / Nadi/ Comefri
Pre-Filters	AAF / Thermodyne / Camfil / Fraudenburg / Dyna Filter
Ventilation Fans	DRI / Flaktwood/Kruger / Nicotra / Greenheck / Nadi
Variable Frequency Drives	Danfoss / ABB / Siemens
MS Pipes	Jindal / Tata / Sail / MSL/ Zenith
Butterfly Valves	Audco / Advance / Intervalve / BDK
Check valve	Normax / Socla / Advance / Intervalve / Audco
Flow Control Valves (Pressure Independent type)	Danfoss / Honeywell / Johnson / Seimens / Belimo / Oventrop
2-Way Modulating & On / Off Valves	Danfoss / Johnson Controls / Honeywell/ Sauter / Seimens / Belimo
Balancing Valves	Belimo / Advance / Oventrop/ Honeywell / Johnson / Seimens
Strainer	Socla / Sant / Advance
Suction Guide	Emerald / Anergy / Armstrong
Pressure & Temperature Gauges	Wika / Fiebig / Waree / Forbes Marshal
Pipe Insulation – Nitrile Rubber	Armaflex / K Flex / A Flex
Pipe Insulation – EPS	Beardsell / Malanpur / Llyods / Styrene
Auto Airvent Valve	Rapid Controls / Flamco / Anergy / Socla
Temperature Sensors / Transmitters	Honeywell / Johnson Controls / Siemens / Schneider
Differential Pressure Sensors / Transmitters / Switch	Honeywell / Johnson Controls / Siemens / Schneider
Galvanized Steel Sheet	TATA / Jindal / Sail
Aluminium Sheet	Nalco / Balco / Hindalco
Duct – Factory Fabricated	Rolastar / Zeco / Alfa / Radiant / Western Air
Duct Insulation – Nitrile Rubber	Armaflex / K Flex / A Flex
Fibre glass	UP Twiga / Owens corning
Air Terminal / Distribution Devices - Grilles, Diffusers, Dampers & Louvers	Caryaire / Air Master / Systemair / Cosmic/ Dynacraft/ TROX / Ruskin / Greenheck / Premier
Fire dampers – UL approved	Greenheck / Ruskin / Trox / Dynacraft / System Air / Ravistar
Welding Electrodes	Advani / Esab / Feroline / L&T
VRF	DAIKIN/Mitshubishi/O'General
Chiller	Trane/Carrier/ DAIKIN/ YORK
Pipe supports	Hitech supports / Hilti / Kanwal Industries

Materials / Equipment	Manufacturer / Make
Paint	Asian / Nerolec / Berger / Shalimar
Fire Sealant	Birla 3 M / Hilti / Promat / GE/ Dow Corning
Vibration Isolator / Flexible Bellow	Kanwal Industries / Resistoflex / CORI / Easyflex / Dunlop
HVLS Fan	Bladetec / Kelleys / Rite-Hite
Copper Pipes	Hindustan / Rajco / Parasmani / Mandev
Ultrasonic / Magnetic/ Turbine Flowmeter	Forbes Marshal / Belimo / Johnson Controls / KRONHE
Volume Control Damper	Greenheck / Ruskin / Ravistar / Trox / Dynacraft/ System Air
Air Curtain	Systemaire / VTS / Russell / Aircon / Mitsubishi
Actuator	Belimo / Honeywell / Johnson Controls / Seimens / L&T / Rotork / Auma
Hot Water Generators	Rapid Cool / KEPL / Emerald
3 Way Mixing Valve	Honeywell /Sauter /Johnson/Siemens
DDC controllers	Siemens / Johnson / Honeywell / GE / Schneider / Delta Controls
Temperature Sensor	Siemens / Johnson / Honeywell / GE / Schneider / Delta Controls / Greystone/ L&T
Pressure Transmitters	Siemens / Johnson / Honeywell / GE / Schneider / Delta Controls / Greystone / Veris / L&T
Differential Pressure Switches	Siemens / Johnson / Honeywell / GE / Schneider / Delta Controls / Greystone / Veris / L&T
Portable Operator Terminal	Siemens / Johnson / Honeywell / GE / Schneider / Delta Controls / L&T
Sensor Cable	Polycab / Finolex / Universal/ Lapp / Geoflex / L&T
P.C	Dell / HP
LED Monitor	LG/ Samsung / SONY / Panasonic / Toshiba / Hitachi
Printer	Epson / Canon / HP

Notes:

1. Specification/brands names of materials to be used as per the scope of work are listed here. The efforts should be made by the agency to use indigenous products. The agency should also consider the availability of spares parts/components for maintenance purposes while proposing any brand/ manufacturer. The materials of any other brand/manufacturer may be proposed for use by the agency in case the brands specified below are not available in the market and/or agency intends to use some other brand better than the brands mentioned in this list. The alternate brand can be used only after the approval of Engineer-in-Charge.
2. ISI marked material shall be preferred among makes of materials as listed above unless otherwise approved by Department

3.. For items not covered in the above list, the sample shall be got approved by competent authority of Dept. prior to use.
4. Samples of materials, fittings etc. shall be submitted by the tenderer and got approved from the Engineer–in-charge, before supply in bulk at site of work. The bulk supply shall strictly conform to the samples approved. The approved samples shall be kept in custody of the Engineer-in- charge, till completion of the work.
5. Makes offered should comply with technical specifications of tender.

BMS SYSTEM – PREFERRED VENDOR FOR BMS EXECUTION

i. Honeywell Building Solution India Ltd.
ii. Schneider
iii. Johnson Control India Ltd
iv. Siemens India Ltd
v. Schweitzer Systemtek India Ltd
vi. GMP Technical Solutions
vii. Kalyani Technologies
viii. Larsen & Toubro

PART-B
FIREFIGHTING WORKS

CHAPTER-1 GENERAL

1.1 INTRODUCTION

1.1.1 Scope
These specifications cover water based fixed firefighting installations.

1.1.2 Related Documents
These General Specifications shall be read in conjunction with the general conditions of contract, tender specifications, schedule of work, drawings and other documents connected with the work. In the event of any discrepancy between these specifications, general conditions of contract and Schedule of Quantities, the Schedule of Quantities shall prevail over all other documents.

1.1.3 Terminology
The definition of terms used in these specifications shall be in accordance with relevant IS.

1.1.4 Site Information
The tenderer should, in his own interest, visit the site and familiarize himself with the site conditions before tendering. For any clarification, tenderer may raise their queries at the pre bid clarification stage.

1.2 CONFORMITY WITH STATUTORY ACTS, RULES, ORDERS, STANDARDS AND CODES
(i) All components and their installation shall conform to relevant Indian Standard Specifications, wherever existing, amended to date. A list of such standards is appended in Appendix-A.

(ii) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2010, NEC 2011 amended to date. They shall also conform to DCSEM General Specifications for Electrical Works.

1.3 SAFETY CODES AND LABOUR REGULATIONS
(i) In respect of all labour employed directly or indirectly for the firefighting work, the contractor at his own expense, will arrange for the safety provisions as per the latest prevalent statutory provisions and instructions issued from time to time. Failure to provide such safety requirements would make the contractor liable for penalty to be decided by Engineer-in-charge. In addition, the Engineer-in- charge, shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost incurred thereon from the contractor.

(ii) The contractor shall provide necessary barriers, warning signals and other safety measures while laying pipelines, cables etc. or wherever necessary so as to avoid accident. He shall also indemnify DCSEM against claims for compensation arising out of negligence in this respect. Contractor shall be liable, in accordance with the Indian Law and Regulations, for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage incurred or claims arising therefrom during the

deemed necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

1.4 SCOPE OF DEPARTMENT

Unless otherwise specified in the tender documents, the following works shall be arranged by the Department:

(i) All contingent civil, electrical and PH works not specifically mentioned in the tender specifications, schedule of quantities and drawings.

In case of composite contracts, having Firefighting work as one of the works, these arrangements shall, however, be in the scope of the principal contracting agency.

1.5 SCOPE OF CONTRACTOR

Unless otherwise mentioned in the tender documents, the following works shall be included in the scope of the contractor and deemed to be included in the tendered cost, whether specifically indicated in the Schedule of Quantities or not: -

(i) Foundations for equipment including foundation bolts and vibration isolation spring/pads,
(ii) Suspenders, brackets and floor/wall supports for suspending/supporting pipes.
(iii) Suspenders and/or cable trays for laying the cables,
(iv) Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, including necessary base treatment and supports.
(v) Sealing of all floor slab/wall openings provided by the Department or made by the contractor for pipes and cables, from fire safety point of view, after laying of the same.
(vi) Power supply, Water supply and Drain points.
(vii) Painting of all exposed metal surfaces of equipment and components with appropriate colour as per para 1.13.
(viii) Making openings in the walls/floors/slabs or modification in the existing openings wherever provided for carrying pipe line, cables etc.
(ix) All electrical works including cable/wires, earthing etc. beyond power supply made available by the department.
(x) Making good all damages caused to the structure during installation and restoring the same to their original finish.
(xi) Approval from local fire authorities as may be required as per local bye-laws.

1.6 MACHINERY FOR ERECTION

All tools and tackles required for unloading / handling of equipment and materials at site, their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

1.7 COMPLETENESS OF THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK

(i) *Completeness of the tender*: -

All sundry equipment, fittings, assemblies, accessories, hardware items, foundation bolts, supports, termination lugs for electrical connections, cable glands, junction boxes and all other items which are useful and necessary for proper assembly and efficient working of the various equipment and

components of the work shall be deemed to have been included in the tender, irrespective of the fact whether such items are specifically mentioned in the tender or not.

(ii) *Submission of programme*: -

Upon receipt of the letter of award, the successful tenderer shall submit his programme for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in-Charge within the time frame as specified in the contract. Items like piping etc. that directly affect the building civil work progress shall be given priority. Hose pipes, branch pipes, first aid hose reel pipes shall be supplied just before commissioning of the system.

(iii) *Submission of Drawings: -*

The contractor shall prepare and submit the site use drawings to the Engineer-in-Charge (as per para 1.7 (ii) above) for approval before commencement of work.

(iv) *Commencement of work: -*

The contractor shall commence work as soon as the drawings submitted by him are approved either in full or in part as the case may be.

1.8 DISPATCH OF MATERIALS TO SITE AND THEIR SAFE CUSTODY

The contractor shall dispatch materials to site in consultation with the Engineer-in- Charge. Watch and ward over the items delivered at site shall be the responsibility of contractor. Programme of dispatch of material shall be framed keeping in view the building progress. Safe custody of all machinery and equipment supplied by the contractor shall be the responsibility of the contractor till final taking over by the department.

1.9 CO-ORDINATION WITH OTHER AGENCIES

The contractor shall co-ordinate with all other agencies involved at the site of work so that the work of other agencies is not hampered due to delay in his work. Piping, cabling or any other work, which directly affect the progress of work of other agencies, shall be given priority.

1.10 QUALITY OF MATERIALS AND WORKMANSHIP

(i) The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.

(ii) The entire work of manufacture/fabrication, assembly and installation shall conform to sound engineering practice.

(iii) All equipment and materials to be used in work shall be manufactured in factories of good repute having excellent track record of quality manufacturing, performance and proper after sales service.

1.11 CARE OF THE BUILDING

Care shall be taken by the contractor during execution of the work to avoid damage to the building. He shall be responsible for repairing all such damages and restoring the same to the original finish at his cost. He shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.

1.12 COLOUR SCHEME FOR THE EQUIPMENT AND COMPONENTS

1.12.1 The entire metal work above ground level shall be painted with red color shade No. 536 of IS:5.

1.12.2 Pump, motor and engine shall be painted with red color shade No. 536 of IS:5

1.13 INSPECTION AND TESTING

1.13.1 Pre dispatch inspection and testing

(i) Initial inspection of materials and equipment at manufacturer's works may be done by the Engineer-in-Charge or his representative. For item/ equipment requiring initial inspection at manufacturer's works, the contractor will intimate the date of testing of equipment at the manufacturer's works before dispatch. The contractor shall give sufficient advance notice regarding the dates proposed for such tests to the department's representative(s) to facilitate his presence during testing. The Engineer-in-charge at his discretion may witness such testing. Equipment will be inspected at the manufacturer/ authorized dealer's premises, before dispatch to the site by the contractor.

(ii) The department also reserves the right to inspect the fabrication job at factory and the successful tenderer has to make arrangements for the same.

(iii) The materials duly inspected by Engineer-in-Charge or his authorized representative shall be dispatched to site by the contractor upon receipt of dispatch clearance from the department.

(iv) No additional payment shall be made to the contractor for pre dispatch inspection/testing at the manufacturer's works by the representative of the Engineer-in-Charge.

1.13.2 Final Inspection and Testing

Final Inspection and testing will be done by the Engineer-in-Charge or his representative as per details indicated in Chapter-8.

The installation will be offered for inspection of local bodies (Chief Fire Officer). The contractor or his representative shall attend such inspection of the Chief Fire Officer, extend all test facilities as are considered necessary, rectify and comply with all observations of the Chief Fire Officer which are part of the agreement and arrange for obtaining necessary clearance certificate in favour of the department. In case the contractor fails to attend the inspection and make desired facilities available during inspection, the department reserves the right to provide the same at the risk and cost of the contractor and impose penalty for the same. The installation will be accepted by the department only after receiving clearance from Chief Fire Officer for the work executed by the contractor under the agreement.

1.13.3 Safety Measures

All equipment shall incorporate suitable safety provisions to ensure safety of the operating personnel at all times. The initial and final inspection reports shall bring out explicitly the safety provisions incorporated in each equipment.

1.14 GUARANTEE

(i) The contractor shall guarantee the complete system to provide the specified flow and pressure under all conditions at outlets.

(ii) All equipment shall be guaranteed for a period of 12 months from the date of acceptance and taking over of the installation by the Department against unsatisfactory performance and/or breakdown due to defective design, material, manufacture, workmanship or installation. The equipment or component or any part thereof so found defective during the guarantee period shall be repaired or replaced free of cost to the satisfaction of the Engineer-in-charge. In case, it is felt by the department that undue delay is being caused by the contractor in doing this, the same will be got done by the department at the risk and cost of the contractor. The decision of Engineer- in-charge in this regard shall be final.

1.15 TENDER DRAWINGS, DRAWINGS FOR APPROVAL AND COMPLETION DRAWINGS

1.15.1 Tender Drawings

The drawings appended with the tender documents are intended to show the areas allotted for various equipment, tentative pipe routes. The equipment offered shall be suitable for installation in the spaces shown in these drawings.

1.15.2 Drawings for approval on award of the work

The contractor shall prepare and submit following drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor of his responsibility to supply the equipment/materials as per agreement. In case of any contradiction between the approved drawings and agreement the decision of the Engineer-in-Charge shall be final and binding on the contractor.

(a) Layout drawings of the equipment to be installed in pump room and terrace
(b) Drawings showing the details of erection of entire equipment including their foundations
(c) Plumbing drawings showing the layout of entire piping, diameter and length of pipes, hydrant, air vessel, valves and isometric drawings showing connections to various equipment
(d) Sprinkler drawing indicating layout and sizes of pipe, location of valves, sprinklers etc.
(e) Electrical wiring diagrams for all electrical equipment and controls including the sizes and capacities of the various cables and equipment
(f) Dimensioned drawings of all electrical and control panels
(g) Drawings showing details of supports for pipes, cable trays etc.
(h) Any other drawing(s) relevant to the work

1.15.3 Completion Drawings

Three sets of the following laminated drawings shall be submitted by the contractor while handing over the installation to the Department. Out of this one of the sets shall be laminated on a hard base for display in the fire control room. In addition, one set will be given on compact disc.

(a) Installation drawings giving complete details of all the equipment, including their foundations,
(b) Plumbing layout drawings giving sizes and lengths of all the pipes and the sizes and locations of all types of valves, and including isometric drawings for the entire piping including the pipe connections to the various equipment,
(c) Line diagram and layout of all electrical control panels giving switchgear ratings and their disposition, cable feeder sizes and their layout,
(d) Control wiring drawings with all control components and sequence of operations to explain the operation of control circuits.

1.16 DOCUMENTS TO BE FURNISHED ON COMPLETION OF INSTALLATION

Three sets of the following documents shall be furnished to the department by the contractor on completion of work: -

(a) Completion drawings as per instructions of EIC.

(b) 3 sets of manufacturer's technical catalogues of all equipment and accessories.
(c) Operation and maintenance manual of all major equipment, detailing all adjustments, operation and maintenance procedure.
(d) Name plate details of all equipment.

CHAPTER-2
FIRE PUMPS

2.1 SCOPE

This chapter covers the general requirements of water pumps for main fire pump, jockey pump and terrace pump.

2.2 TYPE

Pumps conforming to IS 12469 shall be exclusively used for Firefighting purposes. The pumps shall be centrifugal type direct driven with a 3 phase, 415 V ± 10%, 50 Hz, A.C. motor. The standby fire pump shall be driven by diesel engine. The pumps may be centrifugal split casing/end suction/multistage type or vertical turbine type with operating speed, head, flow rate etc. as specified in the schedule. Motor and Engine shall be supplied by the Pump Manufacturer only and along with the pump.

2.3 RATING

The main fire pump and terrace pump shall be suitable for continuous operation in the system. The jockey pump shall be suitable for intermittent operation to buildup pressure in the system on account of leakage. The head and discharge requirements shall be as specified in the tender documents. The head shall be suitable for the system and shall take into consideration the pressure drops across the various components in the water circuit as well as the frictional losses.

The rated discharge of Electric Driven and Diesel Engine Driven pump shall be as specified in SOQ. Pump shall be capable of discharging not less than 150 percent of the rated discharge at a head of not less than 65 percent of the rated head. The shut off head shall not exceed 120 percent of the rated head in the case of horizontal Pumps.

2.4 MATERIAL AND CONSTRUCTION

(i) The centrifugal pumps shall conform to IS 1520.

(ii) The pump casing shall be of heavy section close grained cast iron and designed to withstand 1.5 times the working pressure. The casing shall be provided with shaft seal arrangement as well as flanges for suction and delivery pipe connections as required.

(iii) The impeller shall be of bronze, brass or stainless steel. This shall be shrouded type with machined collars. Wear rings, where fitted to the impeller, shall be of the same material as the impeller. The impeller surface shall be smooth finished for minimum frictional loss. The impeller shall be secured to the shaft by a key.

(iv) The shaft shall be of stainless steel and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.

(v) The shaft sleeve and wearing ring etc. shall be of bronze, brass or stainless steel.

(vi) The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups.

The bearings shall be effectively sealed against leakage of lubricant or entry of dust or water.

(vii) The shaft seal shall be mechanical type, so as to allow minimum leakage. A drip well shall be provided beneath the seal.

(viii) The pumps shall be directly coupled to the motor/diesel engine shaft through a flexible coupling in case of horizontal pumps and rigid spacer type coupling in case of vertical turbine pumps, protected by a coupling guard.

(ix) The pump and motor/diesel engine shall be mounted on a robust bed plate fabricated from mild steel section, which shall be common for the entire pump set in case of horizontal pump. The bed plate shall have rigid, flat and true surfaces to receive the pump and motor/diesel engine mounting feet. The pump will be perfectly aligned with the motor/engine so as to avoid any vibration during operation at all variations of load.

2.5 ACCESSORIES

Each pump shall be provided with the following accessories: -

(a) Sluice valves on suction and delivery.

(b) Reducers, as may be required to match the sizes of the connected pipe work.

(c) Non-return valve at the delivery.

(d) Pressure gauge at delivery side between pump and the non-return valve.

(e) Flexible coupling/connections shall be provided between Pump sets and Valves on suction and delivery sides of all the pump sets.

Note:

1) No butterfly valves shall be installed inside the pump room.

2) The size of the non-return valve and cut off (Sluice valve) shall not be less than the size of the initial delivery pipe.

2.6 INSTALLATION

(i) The pump and motor/engine assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or to the pipe work.

(ii) The pump and motor/engine assembly shall be installed on suitable RCC foundation. The length and width of the foundation shall be such that 100 mm space is left all around the outer edge of the base frame. The height of foundation shall be as recommended by pump manufacturer's drawing. G.I J type anchor bolts and G.I nuts shall only be used for installing the pump on the foundation, the length of the G.I bolts shall be as per the depth of bolt pocket indicated in the pump manufacturer's drawing. The foundation shall be isolated from the floor by vibration isolating pads. Angle iron frame of size 50 mm x 50 mm x 5 mm shall be provided on the top edges of the foundation.

(iii) More than one pump and motor assembly shall not be installed on a single base or cement concrete block.

(iv) The suction/discharge pipe shall be independently supported and their weight shall not be transferred to the pump. It should be possible to disconnect any pump for repairs without disturbing the connecting pipe line.

(v) A minimum clearance of 1 m around the main pumps shall be provided.

For jockey pump-clearance of 75 cm shall be adequate.

(vi) Sufficient space is to be left in front for the radiator of diesel engine for free discharge of hot air. Arrangement for discharging hot air to outside the pump house shall be provided so that hot air does not stagnate in the pump house.

CHAPTER-3
DIESEL ENGINE FOR FIRE PUMP

3.1 SCOPE

This chapter covers the details of requirements of a diesel engine for main fire pump to act as standby.

3.2 GENERAL

The diesel engine shall be suitable for automatic operation complete with necessary automatic starting gear, battery system and shall be complete with all accessories. Both engine and pump shall be assembled on a common bed plate, fabricated from mild steel channel.

3.3 DRIVE

The pump shall be only direct driven by means of a flexible coupling. The coupling between the engine and the pump shall allow each unit to be removed without disturbing the other. Coupling guard shall be provided. The speed shall be 1500 RPM.

3.4 DIESEL ENGINE

3.4.1 ***Environment conditions***- The engine shall be suitable to operate under the conditions of environment at site.

3.4.2 ***Engine Rating***- The engine shall be multi cylinder/vertical 4 stroke cycle, developing suitable HP at the operating speed specified to drive the fire pump. Continuous capacity available for the load shall be exclusive of the power requirement of auxiliaries of the diesel engine, and after correction for altitude, ambient temperature and humidity for specified environment conditions. The engine rating shall be suitable to drive the pump at 150 percent of its rated discharge with at least 65 percent of rated head or 20% in excess of the maximum brake horsepower required to drive the pump at its duty point, whichever is higher. The engine shall have 10% overload capacity for one hour in any period of 12 hours' continuous run.

The engine shall be:

a) naturally aspirated, supercharged or turbo-charged and rather air or water-cooled.
b) provided with an in-built tachometer to indicate rpm of the engine.
c) suitable for cold starting for which suitable heaters shall be provided in lubricating oil.
d) able to develop full load within 15 seconds from the receipt of the signal to start.
e) The diesel engine shall conform to BS 649/ IS 1601/ IS 10002, amended up to date.

3.4.3 Engine Accessories- The engine shall be complete with following accessories:

(i) Fly wheel dynamically balanced

(ii) Direct coupling for pump and coupling guard
(iii) Radiator with hoses, fan, water pump, drive arrangement and guard
(iv) Air cleaner dry type
(v) Fuel service tank with necessary pipe work
(vi) Fuel filter
(vii) Pump for lubricating oil and lub. oil filter
(viii) Electric starting battery 12 V/24 V with 2 Nos. batteries
(ix) Exhaust silencer with necessary pipe work
(ix) Governor
(x) Instrument panel housing all the gauges, including Tachometer, hour meter and starting switch with key (for manual starting)
(xi) Necessary safety controls
(xii) Winterisation arrangement
(xiii) Hand operated semi rotary pump for filling the service tank
(xiv) A standard kit of tools (this shall be kept on hand at all times)

3.4.4 Cooling System- The engine shall be radiator cooled. The radiator assembly shall be mounted on the engine. The radiator fan shall be driven by the engine as its auxiliary with multiple fan belts. When half the belts are broken, the remaining belts shall be capable of driving the fan. Cooling water shall be circulated by means of an auxiliary pump of suitable capacity driven by the engine in a closed circuit.

3.4.5 Fuel System- The fuel system shall be gravity fed from the fuel tank to the engine driven fuel pump. The engine fuel tank shall be mounted either adjacent to the engine or suitably wall mounted on brackets. The fuel filter shall be suitably located to permit easy servicing.

The fuel tank shall be of welded steel construction (3mm thick) and of capacity sufficient to allow the engine to run on full load for at least 8 hours. The tank shall be complete with necessary floor mounted supports, level indicator (protected against mechanical injury) inlet, outlet, overflow connections and drain plug and piping to the engine fuel tank. The outlet should be so located as to avoid entry of any sediments into the fuel line to the engine.

Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position.

All fuel tubing to the engine shall be with M.S.'C' class pipe with flexible hose connections where required. Pipe joints shall not be soldered and plastic tubing shall not be used.

The following shall be provided:
i) A sludge and sediment trap shall be provided.
ii) An inspection and cleaning hole
iii) Means to enable the entire fuel system to be bled of air (Air relief cocks are not allowed; screwed plugs are permitted)

3.4.6 Lubricating Oil System- Forced feed lubricating Oil system shall be

employed for positive lubrication. Necessary lubricating oil filters shall be provided, located suitably for convenient servicing.

3.4.7 **Starting System**- The starting system shall comprise of necessary batteries 12 Volts/ 24 Volts, starter motor of adequate capacity and axle type gear to match with the toothed ring on the fly wheel. Suitable protection to protect starting motor from excessively long cranking runs shall be suitably integrated with engine protection system.
The capacity of the battery shall be suitable for meeting the needs of the starting system.
The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression.
Three attempt starting facility shall be provided. If the engine fails to start after third attempt, the engine shall be locked out and suitable audio-visual alarm shall be given to indicate engine failure. The starter motor used for automatic starting may also be used for manual starting provided there are separate batteries for manual starting.
The scope shall cover all cabling, terminals, initial charging etc.

3.4.8 ***Exhaust System***- The exhaust system shall be complete with residential grade silencer suitable for outdoor installation and silencer piping shall be extended up to 1 m, outside pump house duly insulated with 50 mm thick glass wool and 1.0 mm thick aluminum sheet cladding.
Retrofitted emission-control equipment shall be used having a minimum specified PM-capturing efficiency of at least 70%, type approved by one of the five CPCB recognized labs. (Recommendations of National Clean Air Program 2019 launched by Ministry of Environment, Forest and Climate Change)

3.4.9 ***Engine shut down mechanism-*** This shall be manually operated and shall return automatically to the starting position after use.

3.4.10 ***Governing System-*** The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up to full load. The governor shall be set to maintain rated pump speed at maximum pump load.

3.4.11 ***Engine Instrumentation*** - Engine instrumentation shall include the following: -

(i) Lub. Oil pressure gauge
(ii) Lub. Oil temperature gauge
(iii) Water temperature gauge
(iv) Tachometer
(v) Hour meter

The instrumentation panel shall be suitably mounted on the engine.

3.4.12 ***Engine protection devices*** - Following engine protection and automatic shutdown facilities shall be provided: -

(i) Low lub. oil pressure.
(ii) High cooling water temperature.
(iii) High lub. oil temperature.

(iv) Over speed shut down

3.4.13 ***Pipe work***- All pipe lines with fittings and accessories required shall be provided for fuel oil, lub. Oil and exhaust systems.

3.4.14 ***Anti-vibration mounting***- Suitable vibration mounting duly approved by engineer-in-charge shall be employed for mounting the unit so as to minimize transmission of vibration to the structure.

3.4.15 ***Battery Charger***-

Battery of diesel engine operated fire pump shall have separate charger from emergency power supply circuit. Necessary float and boost charger shall be incorporated in the control section of power and control panel with manual selection of boost charge, to keep the battery under trim condition. Voltmeter to indicate the state of charge of the batteries shall be provided. Where separate batteries are provided for automatic and manual starting, the charging equipment shall be capable of trickle charging both the batteries simultaneously. Equipment shall be provided to enable the state of charge of the batteries to be determined.

3.4.16 The engine installation shall be approved by the representative of engine manufacturer (who shall carry out after sales service under AMC).

3.4.17 The following spare parts shall be supplied with the engine and kept on hand:

a) Two sets of fuel filters, elements and seals;
b) Two sets of lubricating oil filters, elements and seals;
c) Two sets of belts (where used);
d) One complete set of engine-joints, gaskets and hoses;
e) Two injector nozzles;
f) One complete set of piston rings for each cylinder; and
g) One inlet valve and one exhaust valve).

CHAPTER-4
PIPE WORK

4.1 SCOPE

This chapter covers the requirements of pipe work in firefighting installations.

4.2 PLUMBING DESIGN

Pipe sizes shown in tender documents are purely for contractor's guidance. The contractor shall be responsible for selection of sizes as per detailed engineering to be done by him. Plumbing design to be done by the contractor shall incorporate the following: -

(i) (a) Sluice valves shall be provided at suction and delivery sides of pumps.
(b) External hydrant
(c) Fire service connection/inlet.
(d) Test valve.
(e) Drain connections.

(ii) For testing the system healthiness and automatic operation on daily basis, one test (By-Pass) pipe with sluice valve shall be provided in common discharge header. For avoiding wastage of water, this pipe shall discharge water in the tank.

(iii) Non-return valve shall be provided at the delivery of each pump and fire service inlet. This shall be of swing type.

(iv) Air release valves with ball valve shall be provided in the piping system for venting trapped air with a size of 25 mm for pipes up to 100 mm and 40 mm for larger pipes.

(v) Plumbing drawings showing the sizes of pipe, valves, layout and other details shall be prepared and shall be got approved from the Engineer-in- Charge before the execution of the plumbing work.

4.3 PIPE MATERIALS

Pipes shall be of the following materials:

(a) Suction and delivery pipelines of booster pumps, wet riser cum down comer for hydrant system, wet riser for sprinkler system, sprinkler distribution pipes inside the buildings shall be made of GI and shall have beveled ends. All GI piping shall conform to IS 1239 for “Heavy” series (class C). The pipe and fittings shall be able to withstand a hydrostatic test pressure of 5 Mpa (50 Kg/sq. cm) maintained for at least 3 seconds at manufacturing works. The flanged joints shall be provided on both sides of the valves. 3mm thick 3 ply rubber insertions conforming to IS 638 shall be provided between two flanges at the flanged joints with valves.

(b) All MS piping shall conform to schedule 40 seamless pipe, conforming to ASTM 106 A Grade B/ IS-1239 heavy grade(Class-C) as per project requirements and as specified in schedule of quantities. MS pipe joints shall be of welded type.

(c) (i) GI Pipe Medium Class (C-class) conforming to IS:1239 (For Drain)
(ii) Nuts/bolts/washers shall be used.

(iii) Flex drop of stainless steel metallic pipe with mounting accessories, frame for installation on false ceiling.

4.4 PIPE JOINTS

i) Electric welding joints shall be provided in the MS/GI pipe work. Flanged joints shall be provided for connections to valves, pumps, air vessels etc. and also on straight lengths at suitable points to facilitate erection and subsequent maintenance.

ii) Mild steel flanges shall be in accordance with Table - 17 of IS: 6392 i.e. “Plate Flanges for Welding" or as per compatible standards matching with the system operating pressure/pipe specification in line with schedule of quantities and flange thickness shall be generally as under. Gasket thickness shall not be less than 3 mm.

Pipe diameter	**FlangeThick ness**
200 mm	24 mm
150 mm and 125 mm	22 mm
100 mm and 80 mm	20 mm
65 mm	18 mm
40 mm and below	16 mm

iii) All hardware items such as Nuts, Bolts and Washers shall be of appropriate size. Washers shall be used on both sides of the bolt.

4.5 ANTI-CORROSIVE PROTECTION ON UNDER GROUND MS PIPE

Corrosion protection tape shall be wrapped on MS pipes to be buried in ground. This corrosion protection tape shall comprise of coal tar/asphalt component supported on fabric of organic or inorganic fibre and minimum 4 mm thick and conform to requirement of IS: 10221-Code of practice for coating and wrapping of underground mild steel pipe line. Before application of corrosion protection tape all foreign matter on pipe shall be removed with the help of wire brush and suitable primer shall be applied over the pipe thereafter. The primer shall be allowed to dry until the solvent evaporates and the surface becomes tacky. Both primer and tape shall be furnished by the same manufacturer. Corrosion protection tape shall then be wound around the pipe in spiral fashion and bounded completely to the pipe. There shall be no air pocket or bubble beneath the tape. The overlaps shall be 15 mm and 250 mm shall be left uncoated on either end of pipe to permit installation and welding. This area shall be coated in-situ after the pipe line is installed. The tapes shall be wrapped in accordance with the manufacturer’s recommendations. If application is done in cold weather, the surface of the pipe shall be pre- heated until it is warm to touch and traces of moisture are removed and then primer shall be applied and allowed to dry.

Holiday Testing for wrapping and coating is essential. Holiday testing may preferably be carried by flexible and detachable ring probe, which will enable the entire 360o of the surface of the pipe to be scanned.

At least 10 percent of all the welded joints shall be radio graphically tested and

half of the joints radio graphed shall be the 'field joints'.

4.6 VALVES

Each pump shall be provided with a sluice valve on suction side and non-return valve and a sluice valve on the delivery side, the sluice valve being installed on the upstream side of the non- return valve. Pressure gauges shall also be provided on the suction and delivery sides of the pump. The size of the non-return valve and cut off (sluice) valve shall not be less than the size of the initial delivery pipe and, in no case, less than the delivery outlet of the pump. No butterfly valves shall be installed inside the pump room.

Sluice valve shall conform to IS: 780/IS 14846.

Butterfly valve, wherever used, shall conform to IS:13095.

All valves shall be suitable to with-stand the pressure in the system and rating shall be PN 1.6. All valves shall be right handed (i.e. handle or key shall be rotated clock wise to close the valve), the direction of opening and closing shall be marked and an open/shunt indicator fitted.

(i) The material of valves shall be as under: Body - Cast iron
Disc - Cast Bronze or Stainless
Steel Seat - Either integral or Nitrile
rubber O-ring - Nitrite/ Silicon

(ii) Non return valves shall be swing check type in horizontal run and lift check type in vertical run of pipes. Air release valves shall be of gunmetal body.

4.7 ISOLATION VALVES:

(i) Isolation valves shall be provided in the network to enable isolation of any section of the network without affecting the flow in the rest. These valves are distributed according to the general layout of the installation. The isolation valves shall be normally located near the loop junctions. Additional valves shall be provided in the segments where the length of the segment exceeds 300 m.

(ii) Cut-off valves shall conform to IS 780 (PN 1.6 rating)/IS 14846.

(iii) Butterfly valves can be accepted subject to the condition that the valves of diameter exceeding 150 mm shall necessary be of gear operated.

(iv) All Cut-off valves shall be of the right-hand type and enclosed in properly constructed Valve chambers, at least 1 m2 in area so as to allow for broken joints being easily remade. The top of the Valve Chamber shall be 80 mm above ground level, except where it is located on a road. Valve wheels shall have an arrowhead engraved or cast thereon showing direction for turning open and close.
It is recommended that the position of the surface box be indicated by an iron plate painted fire red with distinct lettering. Such plates shall also show the open and close direction as cast or indicated on the valves and the serial number of the sluice valve.

(v) Locations where vehicles can pass shall be avoided for provision of valve below ground.

(vi) In case of installations in earthquake prone zones, flexible couplings shall be used for jointing purposes at required locations.

4.8 Valves in fixed firefighting installations shall have supervisory switch with its signaling to fire alarm panel or to have chain(s), pad lock(s), label and

temper-proof security tag(s) with serial number to prevent tempering/unauthorized operation. These valves shall be kept in their intended 'open' position.

4.9 STRAINERS

Stainless steel strainers shall have minimum 1 mm thick screen with 3 mm perforations. Strainers shall be provided with flanges. Pressure Rating shall be PN 16.

4.10 ORIFICE PLATE

Orifice plate shall be made of 6 mm thick stainless steel and shall have an identification tag projecting beyond any flange between which it is clamped. The orifice shall be plain central hole without burs and diameter not less than one-half of the internal diameter of the pipe to which it is fitted.

4.11 INSTRUMENTS

(i) Pressure gauge of appropriate range and 150 mm diameter size shall be provided.

(ii) The pressure gauge shall be duly calibrated before installation and shall be complete with shut off valve.

4.12 AIR VESSEL

Air vessel shall be provided on top of each riser and shall be fabricated out of 8 mm thick M.S. Sheet. The ends shall be dished. This shall be of 250 mm diameter, 1.2 m high and installed vertically on suitable legs. The legs shall be provided with M.S. Plate of size 75 mm x 75 mm x 5 mm at the bottom so that the legs do not puncture the roof. The legs shall be grouted in concrete foundation. Flange connection shall be provided for connection with wet riser pipe. Air release valve and pressure gauge with shut off valve shall be provided. The air vessel shall be tested at 25 kgf/cm2 pressure before installation.

4.13 INSTALLATION

(i) The installation work shall be carried out in accordance with the detailed drawings prepared by the contractor and approved by the Engineer-in-charge.

(ii) In pipe above ground level, expansion loops or joints shall be provided to take care of expansion or contraction of pipes due to temperature changes.

(iii) Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

(iv) Open ends of piping shall be blocked as soon as the pipe is installed to avoid entrance of foreign matter.

(v) Piping installation shall be supported on or suspended from structure adequately. The contractor shall provide, clamps, hangers etc. in accordance with Para 4.16.

Proper lines and levels shall be maintained while installing exposed pipes.

(vi) Pipe supports in pump house shall be floor mounted and of mild steel/ G. I. Spacing of pipe supports shall not be more than that specified below:

(vii) Anti-vibration pads, springs or liners of resilient and non-deteriorating material shall be provided at each support, so as to prevent transmission of vibration through the supports.

(viii) Pipe sleeves of diameter larger than the pipe by least 50 mm shall be provided wherever pipes pass through walls and the annular spaces shall be filled with felt and finished with retaining rings.

(ix) (a) Vertical risers shall be parallel to walls and column lines and shall be straight and in plumb. Risers passing from floor to floor shall be supported at each floor by clamps as per Para 4.16.

(x) The space in the floor cut outs around the pipe work shall be closed using cement concrete (1:2:4 mix) or steel sheet, from the fire safety considerations, taking care to see that a small annular space is left around the pipes to prevent transmission of vibration to the structure.

(xi) Riser shall have suitable supports at the lowest point.

(xii) Where mild steel pipes shall be buried under ground the same shall be treated in accordance with Para 4.5 before laying. The top of the pipes shall be not less than 1m below the ground level. Where this is not practicable, permission of the Engineer-in-charge shall be obtained for burying the pipes at lesser depth. Masonry or C.C. blocks shall be provided for supporting the pipes at interval in accordance with Para 7.11(vi). After the pipes have been laid, the trench shall be refilled with the excavated soil in layers of 20 cm and rammed and any extra soil shall be removed from the site of work by the contractor.

(xiii) Underground pipe shall be laid at least 2m away from the face of the building preferably along the roads and foot paths. As far as possible laying of pipes under road, pavement and large open spaces shall be avoided. Pipes shall not be laid under buildings and where unavoidable, these shall be laid in masonry trenches with removable covers and cut-off valves shall be provided at points of entry and exit.

(xiv) Pipe over ground shall be painted in red color as per Para 1.13. Suitable identification shall be provided to indicate the run of underground pipe wherever the route of underground pipe cannot be ascertained from the location of yard hydrant/isolating valves.

(xv) It shall be made sure that proper noiseless circulation is achieved in the system. If proper circulation is not achieved due to air-bound connections, the contractor shall rectify the defective connections. He shall bear all the expenses for carrying out the above rectification, including the tearing up and refinishing of floors, walls, etc. as required.

4.14 FLUSHING ARRANGEMENT

Flushing connections with isolation valves should be provided at suitable locations in the firewater ring main.

4.15 PRESSURE TESTING

(a) All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 10 kgf/sq.cm for a period not less than 24 hours. While Hydro Testing, inclusion of cut-off valves in the mains to be tested can be avoided. All leaks and defects in joints revealed during the testing shall be rectified to the satisfaction of the Engineer-in-Charge.

(b) Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

(c) System may be tested in sections and such sections shall be securely capped.

(d) Pressure gauges may be capped off during pressure testing of the installation.

4.16 PIPE SUPPORTS

For installing pipes vertically or horizontally inside the building standard pipe supports of reputed make shall be used. Following supports shall be used.

(i) Split pipe support clamps with rubber lining for vertical, horizontal and roof hanging.

(ii) G.I Clevis Hangers for horizontal supports to adjust varying heights.

(iii) G.I Sprinkler Hangers for horizontal supports for pipes from 15 mm dia to 150 mm dia.

(iv) G.I nuts and fully threaded rods shall be used for installing the pipe supports. The sizes of pipe supports and installation shall be in accordance with manufacturer's recommendations. Some of the typical supports are shown in the Figure-9.

For pipes of size 100 mm and above, with the prior approval of Engineer-in-Charge, 'U' clamp with dash fastener may be used for supporting horizontal pipe from ceiling.

4.17 MEASUREMENT

Measurements of plumbing work shall be on following basis:-

(a) Piping shall be measured along the centre line of installed pipes including all pipe fittings and accessories but excluding valves and other terms for which quantities are specifically indicated in the schedule of work. No separate payment shall be made for fittings and accessories.

(b) The rates for piping work shall include all wastage allowances, flanges pipe supports, hangers, excavation, refilling, testing, nuts and check nuts, vibration isolators, suspension where specified or required, and any other item required to complete the piping installation. None of these items will be separately measured and paid.

CHAPTER-5
FIREFIGHTING ACCESSORIES

5.1 SCOPE

This chapter covers landing valves, first aid hose reels, hose pipes, branch pipes etc., which are vital tools for firefighting.

5.2 LANDING VALVE

Landing valves are provided in the system for connection of hose pipes for discharging water for fighting fire by fire brigade or trained personnel.

5.2.1 The landing valves shall be as per IS: 5290

5.2.2 Material of construction

(i) Body, outlet and cap etc. : Bronze or Aluminum alloy or stainless steel

(ii) Spindle : Brass for Bronze body, stainless steel for Aluminum alloy and stainless steel body.

(iii) Hand wheel : Mild steel or cast iron.

5.2.3 The water discharge shall be not less than 900 lpm for single head valves at 7 kgf/cm^2 pressure.

5.2.4 Installation

5.2.4.1 The landing valve shall be fitted to a T-connection of the riser at the landing in such a way that the valve is in the center of the internal hydrant opening and at a height of 900 mm from floor level.

5.2.4.2 The valve base shall be vertical and the valve facing outside. There should be no hindrance in operation of the handle.

5.3 FIRST AID HOSE REEL

First Aid Hose Reel is meant for delivering small quantity of water in early stage of fire and can be operated even by untrained personnel, and thus provides a most effective firefighting facility. It shall consist of 20 mm (nominal internal) diameter hose tubing length wrapped around a reel with water inlet pipe, stop valve and shut-off nozzle. The entire assembly is mounted on a wall bracket and can swing 180 degrees. The water inlet shall be connected directly to the riser/down-comer mains by means of 37 mm socket and valve. The hose tube can be pulled out easily for the purpose of discharge of water on fire.

5.3.1 First aid hose reel shall be as per IS-884. The coupling, branch pipe and nozzle shall be as per IS:8090.

5.3.2 Material of Construction -

(i) Hub and sides : Aluminum Alloy / Mild steel / Aluminum sheets.

(ii) Wall Bracket : Cast iron / Mild steel.

(iii) Hose tube (20 mm) (nominal internal dia) : Thermoplastic (Textile Reinforced) Type-2 as per IS-12585

(iv) Nozzle with branch Pipe : Brass

(v) Stop Valve(Ball Valve) : Gun metal

Normally M S construction is used. Other material may be used in areas having corrosive atmosphere.

5.3.3 The water flow rate shall be not less than 24 lpm and the range of jet shall be not less than 6 m.

5.3.4 Installation

5.3.4.1 First aid hose reels are installed with internal hydrant space for which is provided. Where space is not provided, first aid hose reel shall be installed in suitable size MS cabinet made from 2 mm thick sheet with glass door. The cabinet shall be painted red. The size of the cabinet shall be such that there is no obstruction in swinging the hose reel. The location of cabinet shall be such that it does not form an obstruction in passage/escape route.

5.3.4.2 The length of hose tube shall be such that the nozzle of the hose can be taken into every room and within a range of 6 m from any part of the room.

5.3.4.3 There shall be no obstruction in swinging the hose reel and should be installed above landing valve where provided.

5.3.4.4 The inlet valve shall be at 900 mm above floor level.

5.3.4.5 Hose reel bracket should be firmly grouted on the wall with the help of rawl bolts.

5.4 FIRE HOSE DELIVERY COUPLING, BRANCH PIPE AND NOZZLES:-

5.4.1 These are important accessories used for firefighting operations.

5.4.2 Material of Construction

5.4.2.1 Copper Alloy

5.4.2.2 Aluminum alloy

5.4.2.3 Stainless Steel

5.4.3 Delivery Hose Couplings

5.4.3.1 The delivery hose couplings consist of male half coupling and female half coupling. Grooves are provided on outer side on both coupling for binding hose pipes with wires. In female coupling spring loaded cam tooth is provided for holding male half coupling in position. Male half coupling and female half coupling are provided on both sides (i.e. on one side male and on other side female) of hose pipes. Two or more pipes can be joined together with the help of these couplings instantaneously.

5.4.3.2 **Sizes**:- These are available in two sizes i.e. 63 mm and 70 mm. Normally size 63 mm is used.

5.4.4 **Branch Pipe and Nozzle** :- Branch Pipes with nozzle are mounted at the end of

hose pipe. Branch pipe is properly finished and free from sharp edges. During operation, a fireman has to hold the branch pipe. One end of branch pipe is fixed with hose coupling and the other end is threaded to fit the nozzle.
Nozzle is tapered pipe with one end threaded internally which is fixed on branch pipe. The size of other end i.e. nozzle shall be 20 mm (nominal internal diameter).
Spare Branch pipes and nozzles to the extent of 10 percent of the above requirements, with a minimum of two sets, shall always be kept readily available in fire control room/pump room.

5.5 FIRE SERVICE INLET AND FIRE SERVICE CONNECTION

5.5.1 These are provided for connection of fire service hose pipes for either directly pressurizing the system with their pumps or filling water in the tank from a distance. In the first case non-return valve with butterfly valve shall be provided for holding water pressure. Fire service inlet shall be provided with each wet riser/down comer and the ring main. The arrangement has been shown in Fig.5. These are fixed to 150 mm diameter pipe and located in MS Box made of 2 mm thick mild steel sheet with openable glass cover.

5.5.2 These shall be as per IS: 904.

5.5.3 Material of Construction

5.5.3.1 Copper Alloy

5.5.3.2 Aluminum Alloy

5.6 HOSE PIPES

5.6.1 Hose pipes shall be rubber lined woven jacketed and 63 mm in diameter. They shall conform to Type A (Re-inforced rubber lined) of IS: 636. They shall be flexible and capable of being rolled. Length of hose pipe will be 15 m.

5.6.2 The hose pipe shall be complete with male and female coupling at the ends as per Para 5.4.3. Besides keeping hose pipe with internal hydrant and yard hydrant, spare hose pipes to the extent of 10 percent of the above requirements, with a minimum quantity of 30 m shall always be kept readily available in fire control room/pump room. Such spare hose shall be in 15 m lengths, readily attached to couplings.

5.7 FIRE EXTINGUISHERS

5.7.1 **ABC Type**; Providing & Fixing ABC type FX of Capacity as per BOQ, conforming to IS Code 15683, trolley mounted or portable, fitted with pressure indicating gauge, internal tube, squeeze lever type, valve fully charged with ABC powder (Mono Ammonium Phosphate), pressured by Nitrogen complete in all respects including wall suspension bracket and conforming to IS 15683-2006. The Fire extinguisher shall be supplied and placed without any damage, scratches and loss of accessories.

5.7.2 **CO2 Type**; Providing & Fixing CO2 type FX of Capacity as per BOQ, Conforming to IS Code 15683, trolley mounted or portable, highly effective against B & C class of fire, having ISI certification mark, having flat base including valve complete in all

respects including wall suspension bracket and conforming to IS 15683-2006. The Fire extinguisher shall be supplied and placed without any damage, scratches and loss of accessories.

CHAPTER-6
AUTOMATIC SPRINKLER SYSTEM

6.1 SCOPE

This chapter covers the general requirement of selection, design, installation, testing, commissioning and maintenance of automatic sprinkler system for firefighting in buildings used for other than industrial, storage purpose, hotels and mercantile buildings.

6.1.1 References: For additional information regarding definitions, planning, design, hydraulic calculations, tables etc. following documents are to be referred to:

(i) IS: 15105: - Design and Installation and Maintenance of Fixed Automatic Sprinkler Fire Extinguishing Systems- Code of Practice (First Revision).

(ii) IS: 9972: - Specification for Automatic Sprinkler Heads for Fire Protection Service (First Revision).

6.2 INTRODUCTION

Firefighting installations described in Para 6.1.1 (i) to (ii) are to be operated manually. Delay in undertaking manual operation due to late detection and or response, may result in spread of fire. In automatic sprinkler system, sprinkler heads are provided throughout the areas to be protected at specified locations such as roof or ceiling, walls, between racks, below obstructions and fitted with water supply lines permanently charged with water under specified pressure. The sprinklers operate at pre-determined temperature to discharge water over the affected area below and provide an adequate distribution of water to control or extinguish fire. Only those sprinklers which are in the vicinity of fire that is those become sufficiently heated operate. Operation of sprinkler results in flow of water which initiates fire alarm. Thus sprinklers perform two functions i.e. first to detect fire and then to provide an adequate distribution of water to control or extinguish it. Water distribution from ceiling level, cools down the hot gas which forms beneath the ceiling of enclosure in which fire is developing. This will prevent spread of fire to adjoining areas and contain damage to limited area.

It should not be assumed that the provision of sprinkler system entirely obviates the need for other means of fighting fire and it is important to consider the fire precaution in the premises as a whole.

The system shall be installed only where there is no danger of freezing of water in the pipes at any time.

Typical layouts of sprinklers have been shown in Figure 11.

6.3 INSTALLATION

***Roofs and ceilings*:**

For conventional and spray type of sprinklers, the sprinklers shall be installed in such a way that the deflectors are at distances below ceilings as shown in Table 6.1.

Table 6.1 Sprinkler Location Below Ceilings

S. No.	Type of ceiling	Distance below ceilings (in mm)		
		Minimum	Maximum	Preferred

(1)	(2)	(3)	(4)	(5)
i)	Combustible, asbestos cement sheets, wired glass and other types of frangible	75	300	150
ii)	Combustible with exposed rafters and/or open joists	75	150	-
iii)	Noncombustible - either plane or arched or sloping	75	450	300

6.3.1 Sidewall Sprinkler Deflector Location and Orientation in relation to building structure:

i) Distance between sprinklers and the ceiling shall not exceed 150 mm. If specifically approved for use and listed so, the distances between ceilings and the sprinklers can be increased up to 450 mm.

ii) Vertical side wall sprinkler deflectors shall be located not more than 150 mm or less than 100 mm from the wall from which they are projecting.

iii) Sprinklers shall be so located to minimize obstructions (to discharge) either on parallel or perpendicular sides thereof. If required, additional sprinklers shall be provided to obviate the obstructions.

iv) **Sidewall Sprinkler Obstruction:** Sprinklers shall be located at least 1.2 m away from any lighting, fan and similar fixtures either in front of or on the same wall where the sprinklers are mounted. For any obstruction (to discharge) including lighting, fan and the like beyond 1.2 m, distances A and B (as indicated in Fig. 6.3) shall be maintained as per the Tables 6.2 and 6.3 given below. In case these distances cannot be maintained, the sprinkler shall not be allowed at such location. (*See* Fig. 9.3).

v) Clearance between the top of storage if any to the deflector shall not be less than 450 mm.

vi) Side wall sprinklers in rooms shall neither be installed above the grills of air conditioner nor within 450 mm thereof on the same wall.

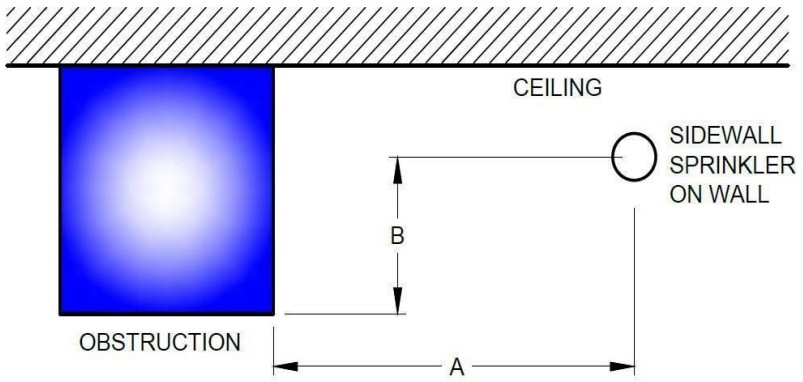
Table 6.2 Sidewall Sprinkler Location in Relation to Obstructions
(lighting, fan and similar fixtures) **-Facing across the wall** (*see* Fig. 9.3)

S. No.	**Distance (A) between Sprinklers and the Obstruction on Side (mm)**	**Maximum allowable Distance (B) between Deflector above bottom of Obstruction when Sprinkler can be allowed**
		(mm)
(1)	(2)	(3)
a)	Up to 1200	Not allowed
b)	More than 1200 but less than 1500	25
c)	More than 1500 but less than 1650	50
d)	More than 1650 but less than 1800	80
e)	More than 1800 but less than 1950	100
f)	More than 1950 but less than 2100	150
g)	More than 2100 but less than 2250	180

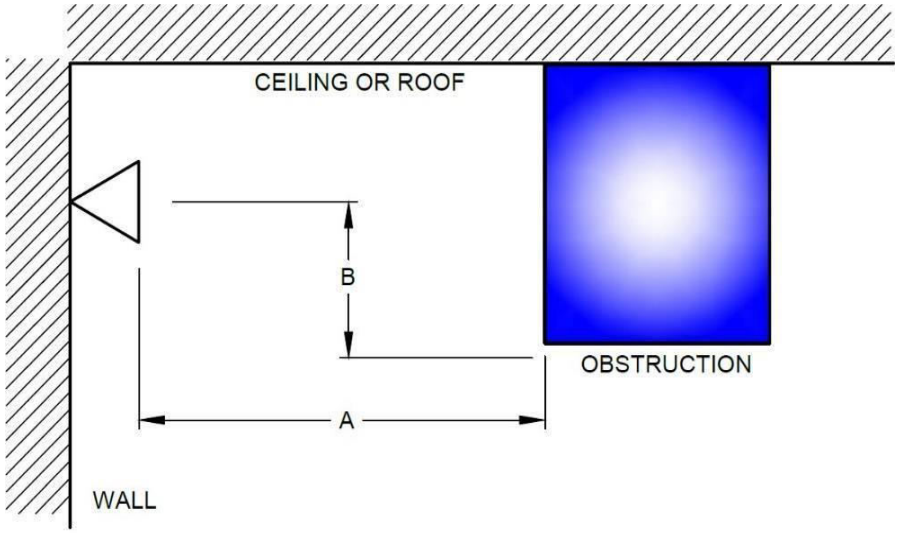
h)	More than 2250 but less than 2400	230
i)	More than 2400 but less than 2550	280
j)	More than 2550	350

Table 6.3 Sidewall Sprinkler Location in Relation to Obstructions (lighting, fan and similar fixtures)-**Along the same wall** (*see* Fig. 9.3)

S. No.	Distance (A) Between Sprinklers and the Obstruction on Side (mm)	Maximum allowable Distance (B) between Deflector above bottom of Obstruction when Sprinkler can be allowed (mm)
(1)	(2)	(3)
a)	100 to 150	25
b)	More than 150 but less than 300	50
c)	More than 300 but less than 450	80
d)	More than 450 but less than 600	115
e)	More than 600 but less than 750	150
f)	More than 750 but less than 900	180
g)	More than 900 but less than 1050	200
h)	More than 1050 but less than 1200	230
i)	More than 1200 but less than 1350	250
j)	More than 1350 but less than 1500	300
k)	More than 1500 but less than 1650	330
l)	More than 1650 but less than 1800	350
m)	More than 1800 but less than 1950	380
n)	More than 1950 but less than 2100	430
o)	More than 2100 but less than 2250	450



ELEVATION VIEW



ELEVATION VIEW

vii) Horizontal sidewall sprinkler shall be located not more than 100 mm and are allowed to be located with their deflectors less than 100 mm from the wall on which they are mounted.

viii) Deflectors of the sprinklers shall be aligned parallel to the ceilings or roofs.

ix) When installed under a sloped ceiling (1 in 6), sidewall sprinklers shall be located at the high point of slope and positioned so as to discharge down the slope.

x) Where vertical side of a beam/projection from a wall is used for installing a sidewall sprinkler, additional sprinklers shall be installed below the soffit if the width of beam or projection from the wall exceeds 200 mm.

xi) When soffits used are within 200 mm in width or projection from the wall, additional sprinklers shall not be required subject to the deflector of the sprinklers falling within prescribed distance as contained in 6.3.7 (ii), (vi) & (vii) above.

6.3.2 Concealed Spaces:-

6.3.2.1 If the height of the concealed space for example between roof and false ceiling is not greater than 0.8m, the spaces shall be sprinkler protected only if they contain combustible materials or are constructed with combustible materials. Electrical cables with voltage less than 250 V, single phase, with a maximum of 15 cables per tray, are allowed.

6.3.2.2 Spaces between roofs and false ceiling more than 0.8 m deep shall be sprinkler protected as follows:-

(i) Concealed spaces less than 5m^2 in area shall not require sprinkler protection.

(ii) Sprinkler heads shall be provided considering the space as any other area in the building.

(iii) Sprinkler heads may be connected individually with the range/distribution pipes below, which shall be sized by taking the room and concealed space sprinklers cumulatively.

(iv) Sprinkler heads for concealed space and for the room may be connected with separate range/distribution pipes connected, with common feed pipe. The common feed pipes shall be not less than 65 mm diameter.

6.3.3 Obstruction below Sprinklers:- Sprinklers shall be fitted under the following

Fig. 9.3 SIDEWALL SPRINKLER OBSTRUCTION ALONGSIDE

types of obstruction which are either:

(a) more than 0.8 m wide and less than 150 mm from the adjacent walls or partitions

OR

(b) more than 1 m wide.

6.3.4 Pipe Sizing and Design: - Sprinkler heads located as per Para 6.3.5 to 6.3.10 shall be connected with pipe lines permanently charged with water. Depending upon location of sprinkler heads and site conditions, sprinkler heads may be connected with range and distribution pipes. A number of options have been indicated in Figure-12.

The pipes connecting the sprinkler heads are to be sized depending upon number of sprinkler heads and arrangement of their connection. Main elements of a sprinkler installation are shown in Figure-11. Various pipes connecting the sprinkler heads are termed as below:

(a) Range Pipe
(b) Distribution Pipe
(c) Main Distribution Pipe
(d) Riser

Sizes of pipes are to be calculated from various tables and hydraulic calculations given in IS: 15105.

Pipe sizes shall be determined using one of the following methods:

a) **Pre-calculated system:** applicable only where light and ordinary occupancies where the aggregate floor plate area (in one or more floors combined) is 5000 m^2 or less (except where gridded or looped layouts are used).
Pre-calculated pipework is applicable only to the extensions of old pre-calculated systems.

b) **Fully calculated system**: applicable for

i) Light and ordinary occupancies where the aggregate floor plate area (in one or more floors combined) exceeds 5000 m^2.

ii) High hazard occupancies,

iii) Storage occupancies, and

iv) All occupancies where conventional and special sprinklers are used like ESFR, LD, EC, intermediate, etc.

Some guidelines relating to pre-calculated system are given below:

a) Pipe less than 25 mm diameter is not to be used.
b) There shall not be more than 6(Six) sprinklers in any range.
c) Range and distribution pipe nominal sizes shall be selected from Table 6.4 and Table 6.5 respectively.

TABLE 6.4
RANGE PIPE NOMINAL SIZES FOR VARIOUS PIPE LAYOUTS IN MODERATE/ORDINARY HAZARD INSTALLATIONS

	Range Pipe Layout	Pipe Nominal Bore (mm)	Maximum Number of Sprinklers to be fed by Pipe of size listed
	(1)	(2)	(3)
(a)	(1) Range(s) at remote end of each distribution pipe spur in end feed layout:		
	(i) Last two ranges in two end-side layout	25	1
		32	2
	(ii) Last three ranges in three end-side layout	25	2
		32	3
	(2) Last range in all other layouts.	25	2
		32	3
		40	4
((B)	All other ranges in case of 1(i), 1(ii) & (2) above	25	3
		32	4
		40	6

TABLE 6.5
DISTRIBUTION PIPE NOMINAL SIZE IN MODERATE/ORDINARY HAZARD INSTALLATIONS AND MAXIMUM NUMBER OF SPRINKLERS

Distribution Pipes	Type of Layout	Distribution Pipe Nominal (mm)	Maximum Number of Sprinklers to be fed by Pipe size listed
(1)	(2)	(3)	(4)
(a) At extremities of the installation	Two end side layouts	32	2
		40	4
		50	8
		65	16
(b) Last three ranges	All other layouts	32	3
		40	6
		50	9
		65	18
(c) Between design points	All	To be calculated as per IS 15105	

and the Installation Control Valve		

Typical pipe sizes for sprinkler installation have been shown in Figure-13. s

6.3.5 Components of sprinkler system: - Following types of valves are used in the installations:

(a) Stop Valves
(b) Test Valves
(c) Drain Valves
(d) Flushing Valves
(e) Check Valves
(f) Installation Control Valves
(g) Pre action valves
(h) Subsidiary valves

The location of above valves shall be as under:

6.3.11.1 **Test Valve**. - For testing hydraulic alarm or electric alarm by drawing water from downstream side, test valve shall be connected with downstream of the water flow alarm.

6.3.11.2 **Drain Valve:** - For drainage of system, drain valve 50 mm diameter shall be provided down stream of Installation Control Valve or any subsidiary stop valve. A common valve can perform the functions of test and drain. The outlet shall be connected with a 50 mm diameter G.I. drain pipe along with riser pipes as shown in figure No. 3 and 4.

6.3.11.3 **Flushing Valve: -** If the water used for sprinkler is not potable, flushing valves shall be provided at the end of a distribution pipe. The valve size shall be same as distribution pipe. Valve outlet shall be fitted with a brass plug and extended to not more than 3 m above floor.

6.3.11.4 **Check Valve: -** Check valve shall be provided where more than one water supply is available and same shall be fitted on each water supply pipe.

6.3.11.5 **Subsidiary Stop Valve: -** Subsidiary stop valve which shall be of the same diameter as the pipe line in which they are fitted shall be provided to control water supply to sprinklers of highly sensitive areas like computer rooms.

6.3.11.6 Installation Control Valve (ICV)**: -** A sprinkler installation shall be fitted with a suitable Installation Control Valve to control the water supply to the installation. The valve set shall comprise of:

(a) a main stop valve.
(b) an alarm valve.
(c) a water motor alarm.

The alarm valve shall be fitted immediately downstream of the main stop valve of each building/block and before any connection is taken off to supply any part of the installation.

The Installation Control Valve shall be placed externally in the vicinity of the main entrance of the building protected at an easily accessible place so that the alarm bell sound is heard by the inhabitants/passer-by. The valve shall be secured open by a pad locked or rivetted strap and protected against impact damage.

If there are genuine constraints in locating the Installation Control Valve outside the buildings, this may be located inside the building in the vicinity of main entrance (subject to approval of authorities concerned). Installation Control Valve in such cases, shall be located away from any exposure to damage and personnel shall be normally available in the vicinity of the location to get alerted by alarm operation. Also, electrically operated sirens interfaced with the opening of the alarm valve of ICV, shall be provided outside the building. In no case, Installation Control Valve shall be provided inside basement or inside pump room.

A plan of the risk with the position of Installation Control Valve shall be placed in a conspicuous location. A location plate shall be fixed near the Installation Control Valve bearing the following words in raised letters:

SPRINKLE R ALARM

6.3.11.7 **Water motor alarm**: Water motor alarm shall be provided very close to the alarm valve. Strainer shall be fitted between the alarm valve and the motor nozzle connection. The water outlet shall be positioned so that any flow of water can be seen. The alarm device shall provide audibility level of 85 dB above the back ground noise level.

6.3.11.8 **Pressure Gauges: -** Pressure gauges shall be provided immediately above and below each alarm valve.

Stop cock shall be provided before pressure gauges for removal without interruption of water supply of the installation. Pressure gauges shall be as per IS: 3624.

6.4 SPRINKLERS TYPE

Sprinklers shall be as per IS: 9972 and following types:

6.4.1 According to type of discharge *(Refer Figure - 15):*

a) Conventional pattern
b) Spray pattern
c) Side wall pattern

6.4.2 According to mounting pattern:

a) Pendent sprinkler
b) Up right sprinkler
c) Horizontal sprinkler
d) Ceiling sprinkler

6.4.3 According to Release Mechanism:

a) Fusible element sprinkler
b) Glass bulb sprinkler

6.4.4 According to Orifice Size:

a) 10 mm
b) 15 mm
c) 20 mm
d) 25 mm

6.4.5 According to Temperature Rating:

Sprinkler shall have one of the following temperature rating and shall be correspondingly color coded:

(a) Fusible Link Type

Temp. Rating °C	Color Code
68/74	Natural
93/100	White
141	Blue
182	Yellow
227	Red

(b) Glass Bulb Type

Temp. Rating	Color of bulb Liquid
57	Orange
68	Red
79	Yellow
93	Green
141	Blue
182	Mauve
204/260	Black

6.5 SELECTION OF TEMPERATURE RATING

Temperature rating of a sprinkler should not be less than 30° C more than the highest anticipated temperature of the location of installation. Under glazed roofs or where there are roof sheets of PVC or similar plastic material, sprinkler shall be rated 73° C to 100°C.

6.6 SELECTION OF ORIFICE SIZE

In moderate hazard applications, sprinklers of orifice size 15 mm shall be used.

Table-9.6 Types of sprinkler

S. No.	HAZARD CLASS	SPRINKLER PATTERN	NOMINAL ORIFICE NOT LESS THAN MM
(1)	(2)	(3)	(4)
i)	Light	Standard, Spray, Flush, Sidewall types	10-15
ii)	Ordinary	All except sidewall types	15
iii)	High	Standard, spray pattern only	15-25
iv)	Storage	Standard, spray pattern only	15-25

6.7 SIZE OF INSTALLATIONS

The protected floor area to be controlled by any one Installation Control Valve shall not exceed 12000 m^2.

As far as possible one area shall be controlled by one Installation Control Valve. If the area is quite large, more than one Installation Control Valve should be planned. Details of area controlled by an Installation Control valve shall be exhibited near it.

If there are more than one block in a campus, each block shall be provided with different Installation Control valve.

6.8 **PROTECTION OF SPRINKLERS**

Any sprinkler installed in a position of risk or accidental damage shall be fitted with a metal guard suitable for sprinkler service.

6.9 WATER SUPPLY ARRANGEMENT FOR SPRINKLER

6.9.1 Pump- Details of pumps to be installed for sprinkler installation are as per NBC 2016 or latest amendment. For large installations, separate jockey pump shall be provided for sprinkler system. All pumps shall have common discharge header. If two electrical pumps are to be provided one non-return valve shall be provided in the header such that sprinkler pump will not feed other system.

6.9.2 Water Storage Tank- The water storage tank shall be combined for other firefighting system and sprinkler installation and the capacity shall be as per NBC 2016 or latest amendment.

6.10 SPRINKLER ANNUNCIATION PANEL AND ALARM

Electrically operated alarm shall be provided for indication of operation of sprinkler in an area. Water flow switches shall be installed in main distribution pipes which shall be wired to sprinkler annunciation panel. In the event of operation of a sprinkler, the flow switch will operate and give signal to the annunciation panel to indicate operation of sprinkler in the area. This will initiate an electrically operated alarm. The system shall be independent of fire alarm

system and compatible with BMS. Necessary potential free contacts for use in BMS should be provided.

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6.10.1 Construction Details

(i) The Panel shall be fabricated out of not less than 2 mm thick MS sheet and powder coated after 7 tank treatment process and shall be totally enclosed dust damp and vermin proof. Suitable knockout shall be provided for the entry of cables. The panel shall be designed such that the equipment for power supply, battery charging are housed in independent compartments. Sealed maintenance free batteries shall also be accommodated inside the panel.

(ii) Indicating lamps control switches, buttons and fuses shall be suitably located in the front and properly labeled.

(iii) The indicating lamps shall be LED type of following colors. The flow switch operation conditions shall be indicated by twin lamps.

(a) Red to indicate flow switch operation.

(b) Amber to indicate fault condition.

(c) Green to indicate healthy condition.

(iv) The test buttons to test the indication lamps shall be provided.

(v) The panel control shall be microprocessor type.

(vi) The primary function of the panel shall be to respond automatically to the operation of one or more flow switches to give alarm and to indicate area/areas where the device has activated. The operation of one or more flow switches shall result in simultaneous alarm given by the following:-

(a) External alarm hooter(s) (provided outside the building to be protected).

(b) A visible indication on panel.

(c) Audible alarm on panel itself (common for all zones)

(vii) The panel shall indicate the fault within the system and immediate fault warning shall be given by an audible and visible signal on the panel in case of open circuit, short circuit and earth fault in cable between flow switch and annunciation panel.

(viii) The panel shall be complete with mimic diagram for the areas covered by different flow switches. The layout of mimic diagram shall be got approved from Engineer- in-Charge.

(ix) Battery backup with trickle cum boost charger shall be provided for operation of the system. Indication of mains failure and the state of charge of the batteries shall be provided. The batteries shall be sealed maintenance free. The capacity of the battery shall be 12 Volt, 2 Nos. 24 Ah each. All standard accessories shall be provided.

6.11 INSTALLATION

The installation shall be carried out as per Chapter 4 and 8. Following additional points are to be taken care for sprinkler installations:

6.11.1 For fixing sprinkler heads, 15 mm diameter M.S. Socket is to be welded to range pipes at the locations as per drawings. Dead plug shall be fixed in the socket.

6.11.2 If sprinkler head is to be provided away from range pipe, M.S./GI Pipe nipple of suitable size be used to extend the sprinkler head and socket is welded at desired location.

6.11.3 After completion of work in sections, pressure testing at 7.5 kgf/cm^2 pressure shall be carried out for 24 hrs.

6.11.4 After completion of the entire work, pressure testing of entire pipe work shall be carried out for 24 hrs. at a pressure of 7.5 kgf/cm^2. The drop of pressure up to 0.5 kgf/cm^2 shall be accepted.

6.11.5 The lines shall be flushed before completion of building work so that any foreign matter which might have entered the system is taken out. The pressurization pump (Jockey Pump) be operated and valves opened at different locations.

6.11.6 During occupation of the building, sprinkler heads shall be provided in place of dead plugs. Teflon tape shall be used on threaded portion. The sprinkler heads shall be properly tightened in the socket.

6.11.7 When all sprinklers heads are installed, pressure is built up in the system by pressurization pump slowly and in case no leak is found, desired pressure is developed and maintained. In case any leak is detected, the same shall be attended before pressurizing the system further.

6.12 COMMISSIONING

As soon as the work is complete, the system shall be commissioned and made available for use in accordance with Para 8.6.

6.13 Spare Sprinklers to be Kept in Stock :

A stock of spare sprinklers shall be maintained in the premises so that prompt replacement is possible after the operation/damage of sprinkler heads. The spares shall be kept in an easily accessible location under conditions where the temperature does not exceed 38°C.

The guidelines as in Table 9.7 shall be followed in respect of stocking spare sprinkler heads.

Spanners or wrenches for the sprinklers shall also be kept along with the spare sprinklers in readiness.

Table 6.13

Guidelines for stocking spare sprinkler			
S. No.	HAZARD CLASS	All state capitals and within 200Km thereof	Other locations
(1)	(2)	(3)	(4)
i)	Light	5 sprinklers of each type	15
ii)	Moderate/Ordinary	15 sprinklers of each type	25
iii)	High & storage	30 sprinklers of each type	50
Note- When there is more than one installation within a complex, the above quantity shall also be increased in proportion. Each type of sprinkler used in the installation such as conventional or spray or ceiling/flush or sidewall sprinklers and appropriate temperatures shall be stocked as per the above requirements.			

CHAPTER-7
ELECTRICAL WORK

7.1 SCOPE

This chapter covers the requirements for the electrical worms associated with firefighting installations, namely, motors, switch boards, power cabling, control wiring, earthing and remote control-cum-indicating panels.

7.2 GENERAL

(i) Unless otherwise specified in the tender specifications, all equipment and materials for electrical works shall be suitable for operations on 415 V / 240 V + 10% (3 phase/single phase), 50 Hz AC system.

(ii) All electrical works shall be carried out complying Central Electricity Authority (Measures Relating To Safety and Electric Supply) Regulations, 2010 and NEC 2011, as amended up to date.

(iii) All parts of electrical works shall be carried out as per appropriate DCSEM General Specifications for Electrical works, all as amended up to date.

(iv) All materials and components used shall conform to the relevant IS specifications amended to date.

7.3 POWER SUPPLY

Power supply to following systems and equipment, where provided, shall be from normal and emergency (standby generator) power sources with change over facility:

a) Fire pumps
b) Pressurization and smoke venting; including its ancillary systems such as dampers and actuators.
c) Terrace pump
d) Fireman's lifts (including all lifts).
e) Exit signage lighting.
f) Emergency lighting.
g) Fire alarm system.
h) Public address (PA) system (relating to emergency voice evacuation and annunciation).
i) Magnetic door hold open devices.
j) Lighting in fire control room and security room.

The generator shall be capable of taking starting current of all the fire and life safety systems and equipment as above. Where parallel HV/LV supply from a separate substation fed from different grid is provided with appropriate transformer for emergency, the provision of generator may be waived in consultation with the Authority.

The electric supply to the pumping set(s) shall be entirely independent of all other equipment in the premises that is even when the power throughout the entire premises is switched off, the supply to the pump shall continue to be available un-interrupted. This can be achieved by taking the connection for the pump(s) from the incoming side of the main L.T. breaker. In case, where parallel HV/LV supply from a separate substation fed from different grid is provided with appropriate

transformer for emergency connected to a common bus bar, the connection may be taken through the bus bars.

The power supply to the panel/distribution board of these fire and life safety systems shall be through fire proof enclosures or circuit integrity cables or through alternate route in the adjoining fire compartment to ensure supply of power is reliable to these systems and equipment. It shall be ensured that the cabling from the adjoining fire compartment is protected within the compartment of vulnerability. The location of the panel/distribution board feeding the fire and life safety system shall be in fire safe zone ensuring supply of power to these systems.

Circuits of such emergency system shall be protected at origin by an automatic circuit breaker so set as to permit the motor to be overloaded during an emergency to the maximum limit permissible by the manufacturer. Further, the no volt coil/the under voltage release of that circuit breaker shall be removed. Master switches controlling essential service circuits shall be clearly labeled.

7.3.1 Independent supply shall be provided for water supply pumps if installed in the same pump house.

7.3.2 If the fire pump house is away from the sub-station building, the route of the cable shall not pass under the building or permanent structure. Cable shall be laid along the route which is safe from fire.

7.3.3 Sufficient spare power shall always be available to drive pumping sets at all times throughout the year. Suitable capacity ACBs/SDFUs shall be provided in the electrical panel for extending supplies to fire pumps. Such switches shall be suitably marked "FIRE SWITCH" and shall not be switched-off without permission/intimation to appropriate authority. In case any maintenance/repair work is to be carried out on the electrical panel where from supplies to fire pumps have been extended, alternative arrangement shall be made to ensure that power supply to fire pumps continue to be available for operation any time.

7.4 MOTORS

The motors shall be squirrel cage AC induction type. The motors shall be suitable for continuous duty and rating necessary to drive the pump at 150 percent of its rated discharge with at least 65 percent rated head. The motor shall be totally enclosed fan cooled type confirming to protection clause IP 21 of IS: 4691. The class of insulation shall be ‘F’. The synchronous speed shall be 1500/3000 rpm as per requirement of the pump. The motor shall conform to IS:325.

7.5 MOTOR STARTER

(i) The motor starter shall conform to IS: 1822 “Motor starters of voltage not exceeding 1000 volts” and shall be air insulated and suitable for 415 V, $\pm$ 10%, 50 Hz, 3 phase AC supply and shall be integrated in the panel.

(ii) Starter for the motor shall be direct on line (D.O.L) for motors up to and including 7.5 H.P. rating and automatic star-delta type for motors of higher ratings unless otherwise specified in the tender specifications. However, for main Fire Pump & Sprinkler Pump Soft Starters may be used.

(iii) Each starter shall be provided with the following protections: -

(a) Thermal overload on all the three phases with adjustable settings,

(b) Independent single phase preventer. (Current sensing type).

(iv) Adequate number of extra NO/NC contacts for interlocks, indicating lamps, remote operation etc. shall be provided on the starter/ contactor.

(v) Under voltage/No volt trip shall not be provided.

7.6 SWITCH BOARDS

(i) The main switch board shall be floor mounted, free standing or wall mounted cubical type and shall be factory built fabricated by one of the approved switch board manufacturer. The board shall be fabricated from 2.0 mm thick CRCA sheet and powder coated after 7 tank treatment process. The board shall be fabricated with IP 42/55 degree of protection as mentioned in SOQ. It shall be suitable for termination of the incoming cable(s) from bottom/top suitable as per site.

(ii) The capacity of switch gear shall be suitable for the requirements of motor fed/ controlled. Starting currents shall be duly considered.

(iii) Switch fuse units shall be used up to and including 32 A and SDFU shall be used for 63 A and above. ACB shall be used for 630 A and above ratings.

(iv) All Switch fuse units/SDFUs shall be of AC 23 duty as per IS: 4064-1978 as amended up to date. They shall be complete with suitable HRC cartridge type fuses.

(v) Switch boards shall house starters for motors with independent current sensing type single phase preventor for each starter.

(vi) Volt meter with selector switch, a set of indicating lamps and fuses for voltmeter and lamps shall be provided. Ammeter with CTs, and selector switch shall be provided with each motor starter. Instruments shall be flush mounted with the panel and have a class index not higher than 1.0. The instruments and accessories shall be provided whether or not specifically indicated in the tender specifications.

(vii) The fabrication of switchboard shall be taken up only after the drawings for the fabrication of the same are approved by the Engineer-in-charge.

(viii) Switchboards shall be fabricated as per specifications indicated in sub-para above.

(ix) The layout shall be designed for convenient connections and inter- connections with the various switchgear. Connections from individual compartments to cable alleys shall be such as not to shutdown healthy circuits in the event of maintenance work becoming necessary on a defective circuit.

(x) Care shall be taken to provide adequate clearances between phase bus bars as well as between phase bus bars, neutral and earth.

(xi) Where terminations are done on the bus bars by drilling holes therein, extra cross section shall be provided for the bus bars. Alternatively, terminations may be made by clamping.

(xii) Provision shall be made for proper termination of cables at the switchboards such that there is no strain either on the cables, or on the terminators. Cables connected to the upper tiers shall be duly clamped within the switchboard.

(xiii) Identification labels shall be provided against each switchgear and starter compartment, using plastic/aluminum engraved labels.

(xiv) Metallic danger board conforming to relevant IS shall be fixed on each electrical switchboard.

7.7 SYSTEM CONTROLLER

For controlling operation of pumps and indicating fault, system controller shall be provided. The system controller shall consist of relays, timer, contactors etc. and shall be designed to operate the fire pumps with interlocking and fault indication.

Annunciation window shall be provided to indicate following faults:

(i) Low water level in UG tank
(ii) Low water level in terrace tank.
(iii) Main pump failed to start.
(iv) Main pump failed during operation.
(v) Diesel pump failed to start.
(vi) Diesel pump failed during operation
(vii) Supply to Main Pump failed
(viii) Supply to Pressurization Pump failed
(ix) Supply to Terrace Pump failed.

Suitable sensors, differential pressure switches, monitors shall be provided at respective locations. The control system shall be operational on 12 Volt/24 Volt DC starting batteries of engine. Battery chargers shall be provided to ensure that the batteries remain charged. Batteries shall be sealed maintenance free type.

7.8 REMOTE INDICATING PANEL

(i) The remote indicating panel shall be provided in the fire control room. This panel shall have necessary status indication of all electric motors.
(ii) Back indication to show the status of operation of all the motors, pressure in the system, water level in underground and overhead tank etc. shall be provided.
(iii) Panel shall be fabricated from not less than 1.6 mm thick CRCA sheet and powder coated after 7 tank treatment process. The panel shall be dust, damp and vermin proof. This shall be of wall mounting type. This shall be complete with necessary termination arrangements, multicore cables, tag blocks, control transformer, designation plastic labels, double earth studs etc. as required.

7.9 POWER CABLING

(i) Unless otherwise specified, the power cables shall be XLPE insulated, PVC outer sheathed aluminum conductor, armoured cables 1100 V grade. The power cables shall be of 2 core for single phase, 4 core for sizes up to and including 25 sq.mm for 3 phase and 3-1/2 core for sizes higher than 25 sq.mm for 3 phase.
Alternatively, XLPE/PVC insulated copper cable (single core/multicore armoured/un-armoured) of grade 1100 V shall be used.

For main power cable(s) from LT Room to Fire Pumps Panel, if the cable(s) is taken in cable trench duly filled with sand & with proper distancing from other cables within the cable trench, or in fire rated shaft, then the cable(s) of above type be used. However, if the cable(s) is likely to be exposed to fire, then fire survival cable(s) shall be used.

(ii) Power cables shall be of sizes to meet the starting and running current of motors fed and shall be as approved by the Engineer-in-Charge, after taking into consideration the load, the length of cabling.

(iii) Cables shall be laid in suitable metallic trays suspended from ceiling, or mounted on walls. Cable ducts shall not be provided in pump rooms. Cable trays shall be of perforated steel sheet with adequate structural strength and rigidity. Necessary supports and suspenders for cable trays shall be provided by the contractor as required.

7.10 CONTROL WIRING

(i) Control wiring shall be done using ISI marked PVC insulated and PVC sheathed,

2.5 sq.mm, 250 V grade, armoured multi-core copper conductor cable. The control cable shall also be laid in the same manner as power cable.

(ii) The number and size of the control cables shall be such as to suit the control system design adopted by the contractor.

(iii) Runs of control wires within the-switchboard shall be neatly bunched and suitably supported/clamped. Means shall be provided for easy identification of the control wires.

(iv) Control wiring shall correspond to the circuitry/sequence of operations and interlocks approved by Engineer-in-Charge.

7.11 EARTHING

(i) Provision of earth electrodes and the type of earthing shall be as specified in the tender BOQ.

(ii) The earth work shall be carried out in conformity with DCSEM Specifications for Electrical works.

(iii) Metallic body of all motors, medium voltage equipment and switch boards shall be connected by two separate and distinct earth conductors to the earth stations of the installations. Looping of such body earth conductors is acceptable from one equipment, or switch board to another.

(iv) The size of earth conductors for body earthing of equipment shall be 2 Nos. 6 mm dia copper wire/2 Nos. 25 x 3 mm G.I. strip

(v) Armoring of cables shall be connected to the body of the equipment/switch board at both the ends. Compression type glands shall be used for all such terminations in the case of PVC/XLPE cables.

7.12 PAINTING

All panels shall be supplied with the manufacturer's standard finish painting or as indicated in the Schedule of Work.

CHAPTER-8
INSTALLATION, TESTING AND COMMISSIONING

8.1 SCOPE

This chapter covers the Installation, testing and commissioning of firefighting system.

8.2 PREPARATION AND APPROVAL OF DRAWING

On award of the work, the contractor has to prepare working drawings as per Para 1.17.2 and submit to the Engineer-in-charge for approval. The work is to be executed as per approved drawings. The stage of approval of drawings is therefore very important. All drawings should be carefully and critically examined before approval. The requirements of various components of firefighting system have been described in previous chapters dealing with the components. However, generally following points are to be taken care while examining and approving the drawings.

8.2.1 Site survey should be carried out in detail.

8.2.2 In addition to building plans, layout plan along with landscape plan/horticulture plan and other services plans should be consulted while deciding route of underground pipes from pump house and around the building.

8.2.3 As far as possible, underground pipe are not to be laid under road, pavement, building and long open spaces. The locations along road, foot path in earth may be preferred.

8.2.4 The location of yard hydrants, fire service inlet and fire service connection are to be decided based on consideration of Para 2.4.1.8 to Para 2.4.1.10. However necessary adjustments are to be made so that these components do not become hindrance in vehicular movement and entrance to the building. Requirement of other building services are also to be given due consideration. Symmetry should be maintained for aesthetic considerations.

8.2.5 Pipe sizes are to be decided in accordance with provision of Para 6.3.10.

8.2.6 **Pump House**:-The layout of equipment in pump house is very important from operation and maintenance considerations. The requirement of pumps and engine have been described in Chapter 5 and 6. In case other equipment i.e. water supply pumps etc. are to be installed in the same pump house, sufficient space shall be left for them as well. The dimensioned foundation drawing of pumps should be available for marking in the pump room layout. The layout is to be prepared in such a way that it should be possible to maintain any equipment without disturbing the adjoining equipment. Electrical panels are to be installed at a location which is easily accessible near the entrance to the pump house and there should be no possibility of water dripping over or near the electrical panel. Typical layout of fire pump house is shown in Figure -10.

8.2.7 **Terrace Pumps:-** The location of pumps and terrace pipe may be decided keeping in view location of terrace tanks for firefighting and other services. The

pipe line should not cause undue hindrance for movement of maintenance personnel at the terrace.

8.2.8 **Electrical Panel** :- Complete wiring drawing, layout etc. are to be examined to ensure that provisions of agreement are incorporated in the drawing. Sizes of various panel and mounting arrangement may be decided keeping in view ease of operation and aesthetic consideration as well.

8.3 INSTALLATION: -

The requirements of installation of various components have been described in previous chapters. However, following precautions are to be taken during execution of the work.

8.3.1 The pump and motor/engine are to be perfectly aligned on the base plate so that there is no vibration during operation. All nuts, bolts, washers shall be of adequate size and galvanized.

8.3.2 The pipe supports should be decided in a way that the weight of pipes and valves are not transferred to the pumps and supports do not cause hindrance in movement inside the pump house. As far as possible, floor supports may be provided in pump house.

8.3.3 All valves shall be installed at a height and in a position that their operation by right hand is conveniently possible.

8.3.4 All pressure gauges should be installed so that the dial is vertical and is visible while entering the pump house.

8.3.5 Electrical panels should not be installed at floor level. The panels shall be sufficiently raised above ground level. If panels are to be mounted on wall, an angle iron frame shall be provided so that at least 75 mm space is left behind the panels. The panels shall be easily approachable.

8.3.6 Cable trays are to be used for laying of power and control cable inside pump house. No cable is to be laid at floor level/in trench. Cable tray layout should give neat appearance. All cable tray shall be adequately supported from the ceiling/floor.

8.3.7 Drain pump shall be installed in the sump provided as per Para 3.2.2 (viii). The pump shall operate automatically for which water level sensor shall be provided.

8.3.8 In no case any structural member i.e. RCC wall, column, beam and floor are to be damaged during installation. Mechanical fasteners are to be used for grouting support.

U.G. tank wall is not to be used for any support. No pipe/cable is to cross the pump house below ground level. Openings above ground level are only to be used for this purpose.

8.3.9 The engine installation work shall be carried out in accordance with the requirement of engine manufacturer and be got approved by the manufacturer

or their authorized service center. The exhaust pipe should be suitably extended outside the pump house so that smoke does not effect nearby structure. Fuel tank shall be properly supported and located in a way that the same does not cause hindrance in movement in the pump house.

8.3.10 While excavating for laying of external pipes, suitable sign board/ barricading shall be provided to ensure that no person falls in the trench.

8.3.11 The width and depth of trench shall be adequate for laying the pipe 1m below ground level.

8.3.12 No earth or any other matter is to be allowed to enter the pipes. The ends shall be kept closed always.

8.3.13 The anticorrosive treatment is to be applied on the entire length laid underground in accordance with Para 7.5. The treatment is not to be damaged.

8.3.14 Pressure testing is to be carried out in sections before filling the earth back in the trench.

8.3.15 The earth filling is to be done in layers of 20 cm each and properly rammed so as to avoid possibility of settlement. Surplus earth/malba shall be removed from the site by the contractor.

8.3.16 Where pipes crossing road likely to have heavy traffic, additional protection over pipe shall be provided to ensure that pipe is not damaged. However, semi-circular RCC Pipes shall be provided over cast iron pipes at road crossings.

8.3.17 External hydrants and fire service connection/ inlet shall be located parallel to the nearby road/ foot path so as to give proper appearance. Foundation shall be raised from below ground level and shall be properly plastered in plumb. The hydrants shall be facing the road/ approach. There shall be no obstruction in approaching the hydrants for operation.

8.3.18 Risers shall be parallel to the wall and in plumb. Adequate supports shall be provided from the wall. Opening around the pipe in slab shall be filled with CC and finished with plaster.

8.3.19 Internal hydrant shall be provided in the center and facing outside for ease of operation. Sufficient space shall be provided around the handle for operation. There shall be no hindrance in moving the first aid hose reel.

8.3.20 Terrace pipes shall be supported on PCC pedestals of adequate height. The pipe route shall be such as no hindrance is created in movement at the terrace. Pipes shall be sufficiently raised above terrace. It is to be ensured that water proofing is not damaged during laying of pipes.

8.4 TESTING

8.4.1 Initial Testing

11.4.1.1 During laying of pipes, the same shall be subjected to 10 kgf/cm^2 hydraulic

pressure for a period of 24 hours, in sections.

11.4.1.2 After completion of the work, all valves/ fittings shall be installed in position and entire system shall be tested for 24 hours at a pressure of 10 kgf/ cm^2. The drop of pressure up to 0.5 kgf/cm^2 shall be accepted.

8.4.2 Final Testing

11.4.2.1 After completion, all operation checks shall be carried out for automatic operation of the systems. For this purpose, landing valves may be opened at different locations. The exercise shall be repeated couple of times to ensure trouble free operation of the system.

11.4.2.2 ***Flow Test***: - The design flow of pumps shall be checked. The pump shall be operated after opening a number of landing valves at different locations. Design pressure is to be maintained in the pump house. Water discharge is to be measured by drop in level in UG tank for a certain period. All pumps shall be tested one by one. The flow rate shall be not less than as specified while maintaining the design pressure in pump house.

8.5 INSPECTION BY LOCAL FIRE OFFICER

After completion of the work and testing to the entire satisfaction of Engineer- in-Charge, the installation shall be offered for inspection by Chief Fire Officer or his representative. Testing as desired by the Fire Officer shall be carried out. The contractor will extend all help including manpower during testing. The observations of Chief Fire Officer shall be part of the agreement. These shall be attended by the contractor. Nothing extra shall be paid for testing as above.

8.6 COMMISSIONING

8.6.1 **Flushing the System**: Before commissioning, the entire system shall be flushed to ensure that any earth/ foreign matters which might have entered during installation are taken out. For this, pump may be operated and valves opened at different locations.

8.6.2 As soon as the work is complete, the system shall be commissioned and made available for use. Requirement of firefighting installations is equally important during occupation of the building. If the building is to be occupied in part, firefighting system of building completed shall be commissioned by isolating the system of under construction portion of the building.

8.6.3 The firefighting system shall be maintained and manned from the very first day of its commissioning.

8.6.4 Any defects noticed during the warranty period shall be promptly attended by the contractor and availability of the system at all time is to be ensured

CHAPTER 09

FIRE ALARM(FA) & PUBLIC ADDRESS(PA) SYSTEM

1. FIRE ALARM CONTROL PANEL

Intelligent addressable microprocessor based Fire Alarm Control Panel (FACP) with "Hot Standby Operating Mode" i.e. not only the microprocessor structure duplicated, but all system structures, components and elements in the fire alarm control panel shall be present in duplicate. The FACP shall be Vds approved & complying to EN-54 standards & shall have the following features and provided with:

Capacity to accommodate minimum of 16 loop cards.

Each loop shall have capacity for accommodating at least 250 detectors / devices in any combination with a loop length up to 1.5 km with 2C x 1.5 sq mm cable.

The occurrence of a fault in the active system causes the system to be automatically switched over to the second system running in parallel and system fault shall be indicated on the panel. All functions, such as detection, triggering of alarms, plain text indication and controlling of fire alarm devices etc. shall remain unaffected. Display & keyboard redundancy is not mandatory.

Redundant controller shall takeover in case of a failure in the Primary Controller.

Redundant loop card, for each loop, shall takeover in case of a failure in the Primary loop card.

Failure of Primary controller shall not affect the working of FA panel. It shall switched to Secondary controller without any manual intervention & shall work in the same manner, as with the primary controller. Necessary devices shall be considered accordingly. There will be alarm/ indication on failure of running one.

All the fire alarm modules (loop cards, networking cards, relay cards Etc.) shall be hot pluggable to facilitate easy replacement of faulty modules.

In case of a Loop Card Failure, the FACP shall allow to replace the Loop card without switching off the panel and reprogramming.

The FACP design shall be modular for the ensuring easy maintenance and seamless functioning of the system, i.e. the internal cards of the FACP shall be arranged such that no other card is disturbed while removing/replacing the faulty module. Modules shall be mounted on only one common bus without any physical contact with one another.

The Fire Alarm Control Panel shall have an operator interface control and annunciation panel with inbuilt buzzer and LCD colour touch screen to clearly indicate the location of fire, type of device activated, other indications like service requirement of a component, etc., and an alphanumeric keypad for the programming and control of the fire alarm system.

It shall be possible to enable, disable or adjust sensitivity of any addressable device through the system keypad on FACP and store events in a non-volatile memory and generate system status reports.

The fire alarm control panel shall contain a history buffer/Log which should be capable of storing large no. of system events, such as fire/fault alarm, warning, status of detectors, alarm acknowledgement /reset etc.with date and time of the event.

FACP shall provide maintenance alert to warn of excessive detector dirt or dust accumulation on detectors.

FACP shall be able to Test the functioning of all modules, detectors, healthiness of loop wiring, etc. by simulating the fire condition and reporting of all the troubles online. Individual loop testing shall be possible.

It shall be possible to Remote Program, configuration and monitoring of FACP via TCP/IP network card via relevant software/dongle.

The FACP shall have facility such that alteration or access to the stored program shall be done through a password, for protection against unauthorized personnel interference.

The fire alarm control panel shall be capable of disabling an individual detector, a group of detectors for building maintenance purposes.

It shall be possible to programme FACP alarm annunciation according to the time. Positive Alarm Sequence selection shall be available during day time that allows a time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within that time, then all local and remote outputs shall automatically activate immediately & alarm shall be immediate during night time. There shall be provision in the FACP to program these at later stage as per site conditions during commissioning of the system.

It shall be possible to program sensitivity of the system can for holidays & office days.

Main Power Supply shall operate on 230 VAC, 50 Hz, and provide all necessary power for the FACP and shall incorporate a battery charger.

Main Power Supply shall be redundant in nature & can accept at least two different incomers & also shall have a battery backup to give supply for minimum of 48 hours in normal conditions and 30 minutes in alarm condition, in case of failure of mains power.

The fire alarm control panel shall annunciate failure of normal power supply audio-visually on main panel as well as on repeater panels.

The FACP shall be capable of soft integration with PA system.

The FACP shall have false alarm reduction algorithms to reduce false alarms due to Dirt/Dust/Disturbance values etc. & shall also have EMC/EMI Monitoring to monitor interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals…etc. The panel shall display the EMI/EMC Current and Average Values reported by the detector. The User/Installer shall have access to this reading during Maintenance (with password protection).

2. Active Repeater Panels

The repeater panel should be Vds approved and complying to EN-54 standards & shall be provided with following features:

The active Repeater Panel shall be a mimic of the main panel i.e. completely same as main

panel without loop cards. The MMI of the Repeater Panel shall be similar to that of the main Control panel.

Audio visual Alarms shall be generated in case of fire. It shall be equipped with an in built buzzer/hooter, which can be silenced locally or from the main control panel itself.

It shall have push buttons for Silence/Mute, Acknowledge, Reset tc. Pressing any of these switches shall cause relevant action to be initiated from the control panel.

The Repeater Panel shall display messages like Alarm & Fault similar to the Main Panel and shall be accessed only by Authorized Users through a passcode to Acknowledge/Reset Alarms.

The Power supply to the Repeater Panel shall be supervised & drawn from the Main FACP.

3. Passive Repeater Panel

The repeater panel should be Vds approved and as per EN-54 standards & shall have the following properties:

The Passive Repeater Panel shall be only for display purpose & shall display Messages like Alarm & Fault similar to the Main Panel.

It shall not be possible to Acknowledge/Reset Alarms through passive repeater panel.

The Power supply to the Repeater Panel shall be drawn &supervised from the Main FACP.

4. Intelligent Addressable Multi sensor Detector

The Intelligent Addressable Multi sensor Detector shall be Vds approved, confined to EN 54-Part 5, 54-Part 7, 54-Part 17, 54- Part 29 & shall have the following features:

It shall be combination of Smoke detection and Heat detection. It shall be possible to program the detector, through software, to work as smoke or heat or combination of both.

All the detectors shall have a visible LED with 360 degree visibility to indicate the healthiness / alarm condition of the detector.

If the visibility of the detector is obstructed by cable trays, false ceiling etc. The detector shall have the facility to connect it to a response indicator. The response indicator shall derive the power, to glow, from the loop.

It shall have a Built in signal-processor along with inbuilt fault isolators to facilitate the isolation of device as well as particular section of loop.

It shall have drift compensation facility built in. It shall be possible to change sensitivity settings of detector based on day/night mode or with schedules based on the programming.

Detector shall provide Maintenance alert at panel for excessive detector dirt or dust Accumulation.

The Detector shall monitor EMC/EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together

avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, lamps, network switches, mobile signal etc.

The detector shall be capable of detecting all types of fires from TF-1 to TF-8 as per EN-54 & all classes of heat as per EN-54 part 5,7 & 29.

In case of a failure, it shall be possible to replace the detector with the same type without the need of additional programming / reprogramming.

5. Addressable Manual Call Points:

The MCP shall be Vds approved according to EN 54 – Part 11, EN 54- Part 17 & shall have the following features:

Manual call points shall be of Double action- break glass type with Push Button.

MCP shall be Loop powered &shall comprise of an electronic circuit in-built to provide addressing capability.

The MCPs shall be provided with inbuilt fault isolators to facilitate the isolation of device as well as particular section of loop & have a LED to indicate Alarms.

Protection category: IP 54 or better

6. Addressable loop powered Sounder:

The Sounder shall be Vds approved according to EN-54 Part 3 standards & shall have the following features:

The Sounder shall be an Addressable loop powered sounder having inbuilt fault isolators to facilitate the isolation of device as well as particular section of loop.

The sounder shall have a sound pressure level of at least 89dB at 1 meter distance and it is possible to adjust the tones & volume from the Main Fire Alarm Panel.

The sounder shall be capable of programming at least 4 different tones for alarm detection in different floors or at different time intervals.

The Volume levels & tones for Testing and Drill shall be programmed as per site conditions.

7. Addressable loop powered Flasher:

The addressable flasher shall be Vds approved according to EN-54 Part 3 standards & shall have the following features:

It shall be loop powered, addressable having inbuilt fault isolator to facilitate the isolation of device as well as particular section of loop.

It shall have configurable flash rate that can be adjusted from FACP.

Color of housing & lens shall be RED.

8. Remote Indicators:

The Remote indicator used in this Building shall confine to the relevant standards having the following features

The remote indicator is used when the automatic detector is installed in a place hidden or not visible like in closed rooms, false ceilings, walls etc.

The remote indicator should have 360° view, for both wall mount and ceiling mount.

It shall control and power directly via the alarm output of the fire detector or a suitable loop module.

9. Control relay module (CRM) / Output module:

The Output module shall be Vds approved according to EN-54 standards & shall have the following features:

The CRM shall provide a dry potential/potential free contact output for activating relay of emergency exits, Elevators etc.

The CRM shall have inbuilt fault isolator to facilitate the isolation of device as well as particular section of loop.

It shall have a capability of handling at least 1A @ 30VDC to integrate with third party system.

In case of loss of the loop voltage, a fail-safe position shall be programmed for the output

Graphical User Interface(GUI) software:

GUI software is required to be installed on 2 nos. of Desktop PCs at different locations with following:

All necessary Dongles, Licenses etc. shall be provided accordingly. (1 no. of PC shall have all the administrative rights & 1 no. of PC shall have only viewing rights).

Providing Desktop PC is in Department's scope. The PC's shall be provided with window 7/8/10 OS (32/64 bit).

Typical floor layout of V.S.Bhavan will be provided in Autocad format by department. The scope of work also includes preparation of Autocad drawings for GUI software indicating location of devices and loops.

GUI software shall provide automatic pop-up of activated device indicating the exact location in the uploaded drawings.

GUI software shall provide automatic pop-up of fault indicating the exact location of fault on the uploaded drawings.

I.PA SYSTEM:

The PA system shall provide facility to make public broadcasts of routine, situational, important and emergency announcements. The PA system shall provide simultaneous broadcasting of calls to all or selected locations. The PA system is also the medium to broadcast background music to all or selected locations. The PA system shall provide an automatic announcement facility for making routine, situational and emergency announcements.

1. System controller

IP based Digital Voice Evacuation cum public address system shall be EN54-16 certified and shall be provided with min. 14 Zones can be expandableup to min. 4 call stations&up to min.

50 loudspeaker circuits. The system shall be provided with the following features:

Completely digital audio and control data transmission

Speaker line supervision in each zone for short circuit fault, discontinuity, ground fault and speaker fault, automatic isolation in case of short circuit.

Input module for at least 4 audio

Possible to send same message simultaneously to several zones,

Built in message manager to store emergency or business-calls

Gain adjustment in the inputs and outputs

Priority for emergency voice alert like fire or any other emergency services

Zone status LEDs, system status LEDs etc.

The controller shall supervise cabling to the amplifier, surveillance of each amplifier, surveillance of the entire signal path, surveillance of individual module in the system & overall fault indication.

2. Call Station

Digital call station shall be EN54-16 certified, designed in a modern and robust chassis with built-in numerical keypad, having gooseneck microphone, suitable for extension up to min. 2 remote call station extensions, each with at least 20 free customizable functions and selection push buttons (14 for zones &at least 6 for other functions) with at least two LEDs per button, menu/function keys (pre-programmed), suitable for connection with controller via network cable up to 500 meter etc.

3. Amplifier

Amplifier shall be digital 1000W (Total) Class D, high efficiency Power Amplifier/Amplifiers EN54-16 certified system device with Short Circuit & Overload Protection, permanently monitored by the system controller having special standby provision for saving energy during the time the amplifier is not is use, 4 channel input, LED indication for the status etc. & shall have following features:

240W RMS per Channel

Amplifier Output voltage 100V

Supply input AC 230 +/- 10% - 50/60Hz

Short Circuit, Power, Temperature, Overload & Short circuit Protection, Automatic Standby etc.

4. 6 W WALL MOUNT SPEAKER

Speaker shall be EN54-24 certified 100V, 6W with wall mounting cabinet having tapings at 6W / 3W/1.5W complete with necessary mounting hardware & accessories.

5. Cabling (For both FA & PA):

The loop cabling shall be done as per NFPA Style 7 (Class-A type) circuit suitable for length of up to 1.5 km (at least) for each loop as per SOQ.

i. Laying Of Cables:

Before cable erection, phase to phase, phase to neutral and phase to earth insulation and continuity of the conductor shall be ascertained.
Sharp bends shall be avoided. The bending radius shall not be less than as specified in IS. Cables shall be laid in the routes marked in drawings. Where the route is not marked, the contractor shall mark it out on the drawings and also on the site and obtain the approval of the departmental engineer before laying the cable. Procurement of cables shall be on the basis of actual site measurements.

ii. **Testing at manufacturer works**:

a) For cable lengths **greater than 2 Km**, all acceptance tests as per IS shall be carried out by the supplier at their works in the presence of departmental engineer. Certificates of all routine & type test shall also be provided.

b) For cable length **less than 2 Km,** only certificates of all routine, type & acceptance tests shall be provided.

iii. SITE TESTS :

The following tests shall be carried out:-

Continuity test:

The continuity shall be established with multimeter.

Insulation resistance test:

The insulation resistance shall be measured between phase, phase to neutral and phase to earth before and after high voltage power frequency test.

Note: Test reports for the electrical installations shall be submitted.

The details of existing system which need to be dismantled:

Existing system is conventional Ravel make system with concealed wiring. Following are the details-

- Main FA panel – 01 no.
- Active Repeater Panel – 01 no.
- Passive Repeater Panel – 14 nos.
- Smoke Detector - 865 nos. (approx.)
- Heat Detector – 07 nos. (approx.)
- MCP – 42 nos. (approx.)
- Hooter – 57 nos. (approx.)
- Response Indicator – 310 nos. (approx.)
- PA panel – 01 no.
- Speakers - 50 nos. (approx.)

APPENDIX—A

PREFRERRED MAKE OF MATERIALS

S	DESCRIPTION OF ITEM	MAKES
1	GI pipes	Tata/Zenith/ITC/Jindal
2	M.S. seamless Pipe	Indian seamless/Jindal/ Tata/Maharastra Seamless
3	C.I. gate valves (Sluice Valves)	Leader/ /Audco
	NRV	Normex/Leader/Advance
3	GM or Copper alloy Gate / Peet/Check Valve	Neta/Sant/Kingston//leader/Zoloto/NEW
4	Stand post Hydrant	Kejriwal/Orient/Durga/Kamla/Janta
5	Pumps	Kirloskar/ Mather&Platt/Grundfoss /KSB/Bel & Gosset/Armstrong/HD Fire
6	Motors	Siemens/ABB/Crompton
7	M.S. chequered sheet	Tata/HSL
8	G.I. Malleable fittings	PEC/MJM/Unik/Zoloto/ 'R'
9	Pressure Gauge	Fie-big/H-Guru
1	SBR/EPDM Gaskets	Prabhat/Orient/Paul/Durable
1	Pressure switch	Danfoss/Indfoss/Switzer
1	Air Vent Valves	Durga / Mayur / IVC / Leader / Hawa
1	Fire hydrant valves	New age/Arihant/Hiren/Safex/ Firestone Indor
1	Fire hose, First aid hose reel, Branch pipe , Siamese connections, Hose coupling, Nozzle, Fire brigade connections etc.	Firex/Minimax/Safex/New Age/Arihant/Bhogilal/ Hiren
1	Paints	Asian paints / Berger Paints/Jenson Nicholson/ICI Paints/Berger (British) Paints/ Garware paints Ltd.
1	Pipe Coat material (Pipe protection)	PYPECOAT / IWL

Notes:-

1. Specification/brands names of materials to be used as per the scope of work are listed here. The efforts should be made by the agency to use indigenous products. The agency should also consider the availability of spares parts/components for

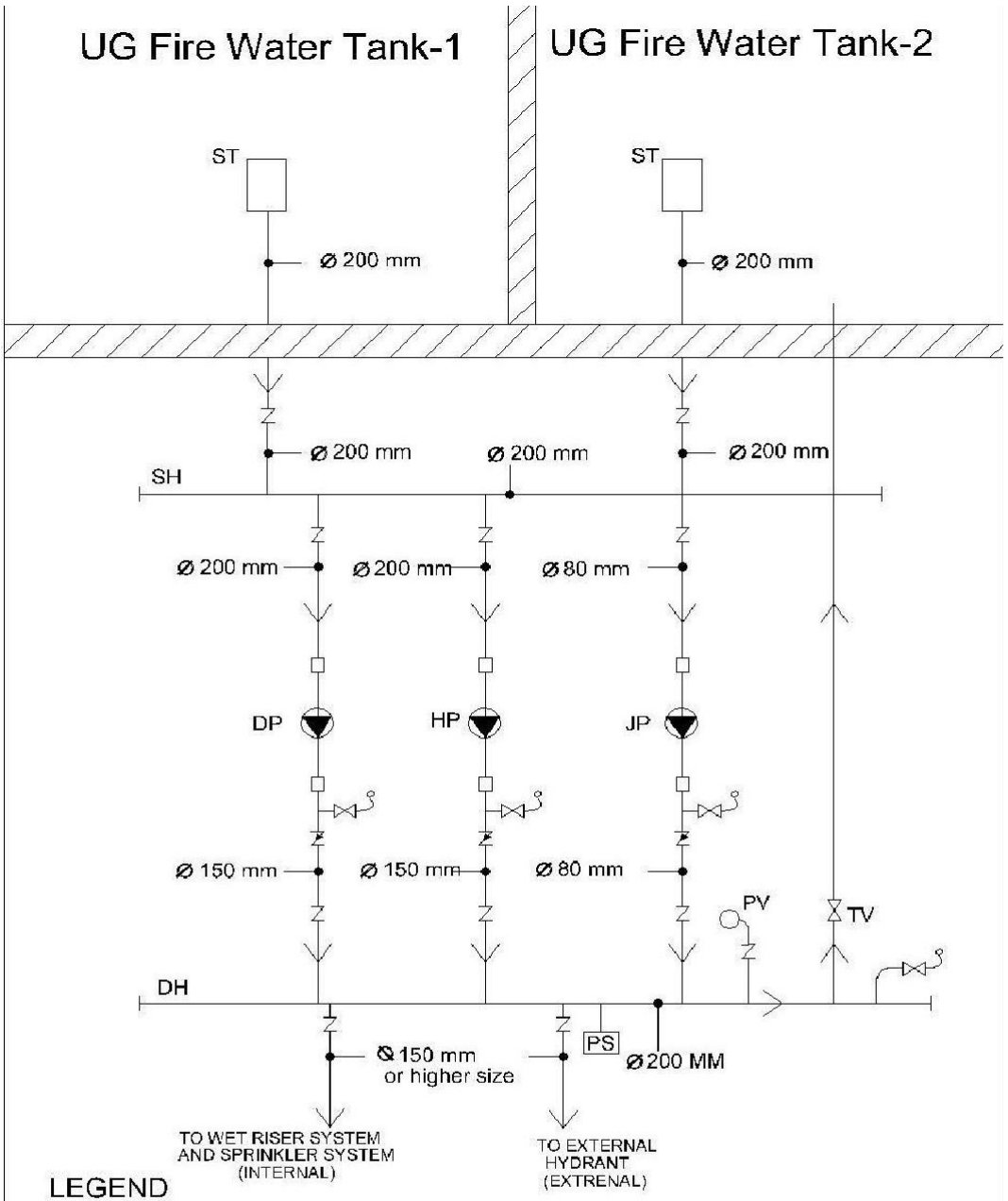
maintenance purposes while proposing any brand/ manufacturer. The materials of any other brand/manufacturer may be proposed for use by the agency in case the brands specified below are not available in the market and/or agency intends to use some other brand better than the brands mentioned in this list. The alternate brand can be used only after the approval of Engineer-in-Charge.

2. ISI marked material shall be preferred among makes of materials as listed above unless otherwise approved by Department
3. . For items not covered in the above list, the sample shall be got approved by competent authority of Dept. prior to use.
4. Samples of materials, fittings etc. shall be submitted by the tenderer and got approved from the Engineer–in-charge, before supply in bulk at site of work. The bulk supply shall strictly conform to the samples approved. The approved samples shall be kept in custody of the Engineer-in- charge, till completion of the work.
5. Makes offered should comply with technical specifications of tender.

APPENDIX—B
LIST OF RELEVANT INDIAN STANDARDS

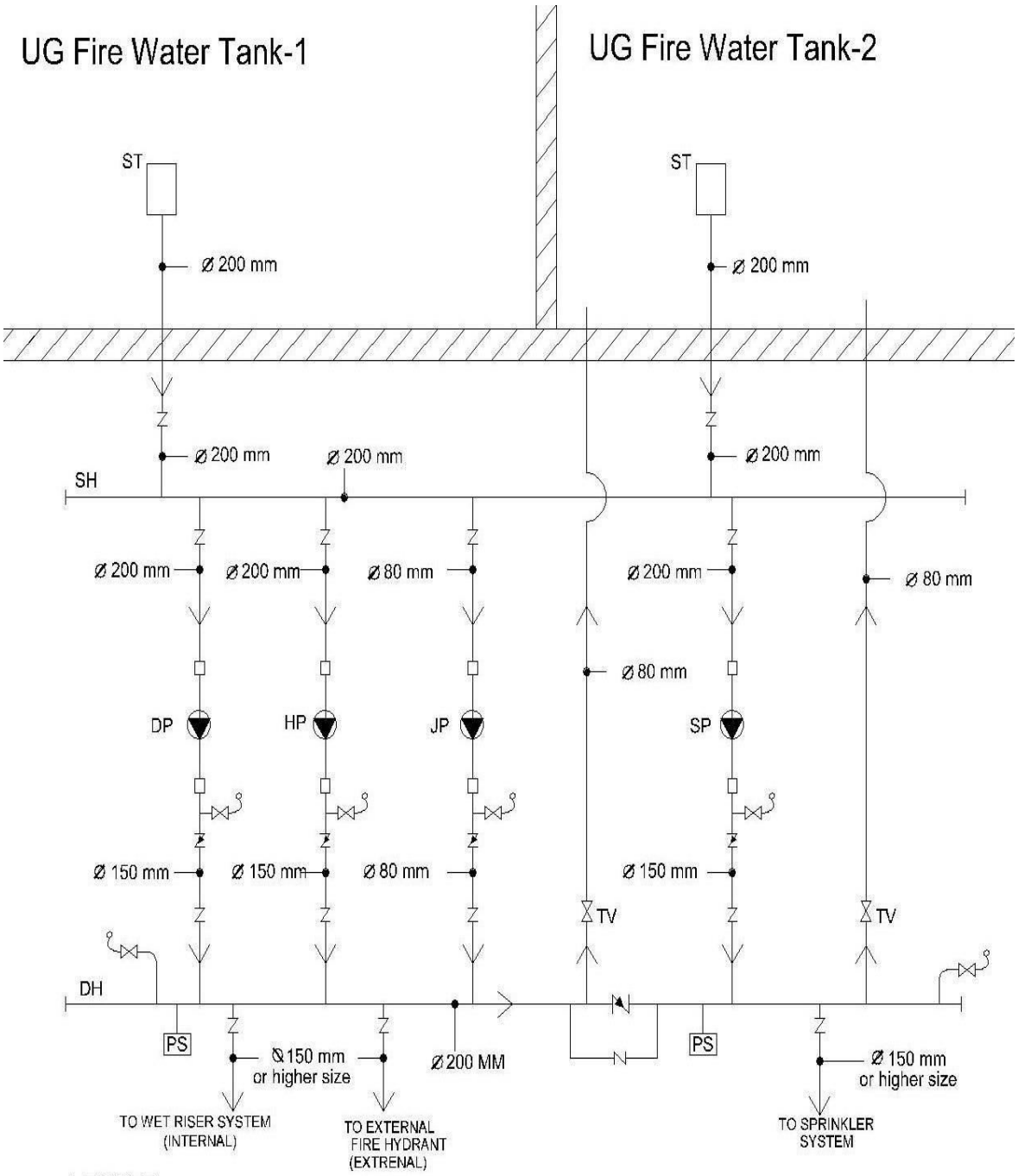
S. No	IS No.	Title
1)	IS-8757	Glossary of terms associated with Fire safety
2)	IS-884	Specification for first-aid hose reel for firefighting
3)	IS-901	Specification for couplings, double male and double female instantaneous pattern for firefighting,
4)	IS-902	Specification (for suction hose couplings for firefighting Purposes (third revision)
5)	IS-903	Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner. (fourth revision)
6)	IS-904	Specification for two and three- way suction collecting heads for firefighting purposes.
7)	IS-907	Specification for suction strainers, cylindrical type for firefighting purpose. (second revision)
8)	IS-908	Specification for fire hydrant, stand post type. (second revision)
9)	IS-909	Specification for underground fire hydrant. Sluice valve type
10)	IS-636	Specification for Non percolating flexible firefighting delivery hose.
11)	IS-7637	Glossary of terms for firefighting equipment.
12)	IS-937	Specification for washers for water fittings for firefighting purposes.
13)	IS-1641	Code of practice for fire safety of buildings (general): General Principles for fire grading and classification.
14)	IS-1642	Code of practice for fire safety of buildings (General) : Details of construction. (second revision)
15)	IS-1643	Code of practice for fire safety of buildings (general) ' Exposure hazard. (first revision)
16)	IS-1644	Code of practice for fire safety of buildings (general):Exit requirements and personal hazard. (second revision)
17)	IS-1646	Code of practice for fire safety of buildings(general): Electrical installations. (third revision)
18)	IS-2871	Specification for branch pipe, universal for firefighting purposes.
19)	IS-2930	Functional requirements for hose laying tender for fire brigade use.
20)	IS-5290	Specification for landing valves.
21)	IS-8090	Specification for couplings, branch pipe, nozzle, used in hose reel tubing for firefighting.
22)	IS-8442	Specification for stand post type water and foam monitor for firefighting (first revision)
23)	IS-9972	Specification for automatic sprinkler heads. (first revision)
24)	IS-11101	Specification for extended branch pipe for fire brigade use
25)	IS -12349	Fire protection Safety sign.

26)	IS -12407	Graphic symbols for fire protection plan.
27)	IS -9668	Code of practice for provision and maintenance of water supplies and firefighting.
28)	IS -3844	Code of practice for installation and maintenance of internal fire hydrants and hose reel on premises.
29)	IS -12585	Specification for thermoplastic house (Textile Reinforced) for Water General purpose.
30)	IS -10221	Code of practice for coating and wrapping of underground mild steel pipe lines. (first revision)
31)	IS-15105	Design and installation of fixed automatic sprinkler fire extinguisher system-Code of Practice.
32)	IS -325	Three phase induction motors.
33)	IS-1822	AC Motor starter for voltage not exceeding 1000 volts.
34)	IS -3624	Pressure and vacuum gauges.
35)	IS-1520	Horizontal centrifugal pumps for clear, cold, fresh water.
36)	IS-1239	Mild steel tubes, tubulars and other wrought steel fittings.
37)	IS -3589	Specification for Steel pipes for water, and sewage
38)	IS -6392	Steel pipe flanges.
39)	IS -778	Specification for copper alloy gate, global and check valves and water works purpose (fourth revision)
40)	IS -2592	Recommendation for methods of measurement or fluid flow be means of orifice plates and nozzles.
41)	IS -732	Code practice for electrical wiring installations.
42)	IS 900	Code of practice for installation and maintenance of induction motors.
43)	IS -1248	Direct acting electrical indicating analogue electrical Measures and their accessories general requirement instruments.
44)	IS-2516	A. C. Circuit breakers for voltages not exceeding 1000 volts.
45)	IS -4047	Heavy duty air break switches and composite units of air break switches and fuses (for voltage not exceeding 1000 volts.
46)	IS -2208	HRC cartridge fuse links up to 650 volts.
47)	IS -1554 (Part I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 volts.
48)	IS:1536	Specification for Centrifugally Cast (Spun) Iron pressure pipes for water, gas & sewage (first revision)
49)	IS 1537	Specification for Vertically Cast Iron pressure pipes for water, gas & sewage (first revision)
50)	IS:1538	Specification for Cast Iron Fittings for pressure pipes for water, gas & sewage (third revision)
51)	IS:780	Sluice valve for water works purposes (50 to 300 mm size)
52)	IS:13095	Butterfly valves for general purpose.
53)	IS:13039	Code of practice for provision and maintenance of External Hydrant System (first revision)



TYPICAL LAYOUT OF FIRE PUMP HOUSE WITH ONE ELECTRIC AND ONE DIESEL FIRE PUMP

FIG. 1



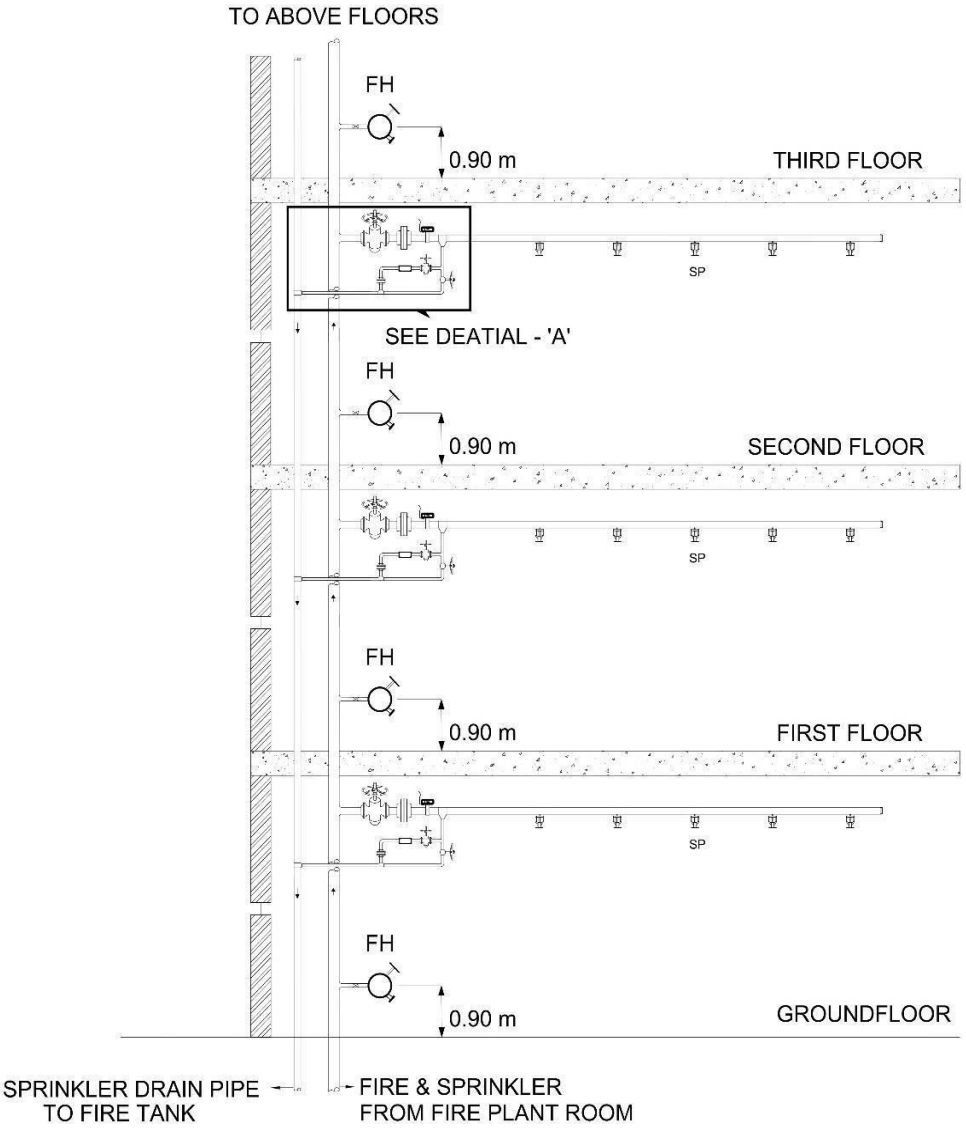
LEGEND

SH SUCTION HEADER
HP HYDRANT PUMP / MAIN ELECTRIC PUMP
JP JOCKEY PUMP / PRESSURISATION PUMP
DP DIESEL PUMP
SP SPRINKLER PUMP
DH DISCHARGE HEADER
ST STRAINER
PS PRESSURE SWITCH
PV PRESSURE VESSEL

PUMP
SLUICE VALVE
PRESSURE GAUGE
TEST VALVE (TV)
FLEXIBLE CONNECTION
NON RETURN VALVE

TYPICAL LAYOUT OF FIRE PUMP HOUSE WITH TWO ELECTRIC AND ONE DIESEL FIRE PUMP

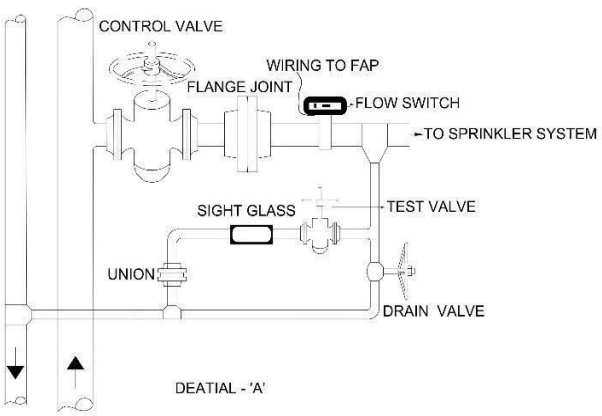
FIG. 2



ELEVATIONAL VIEW

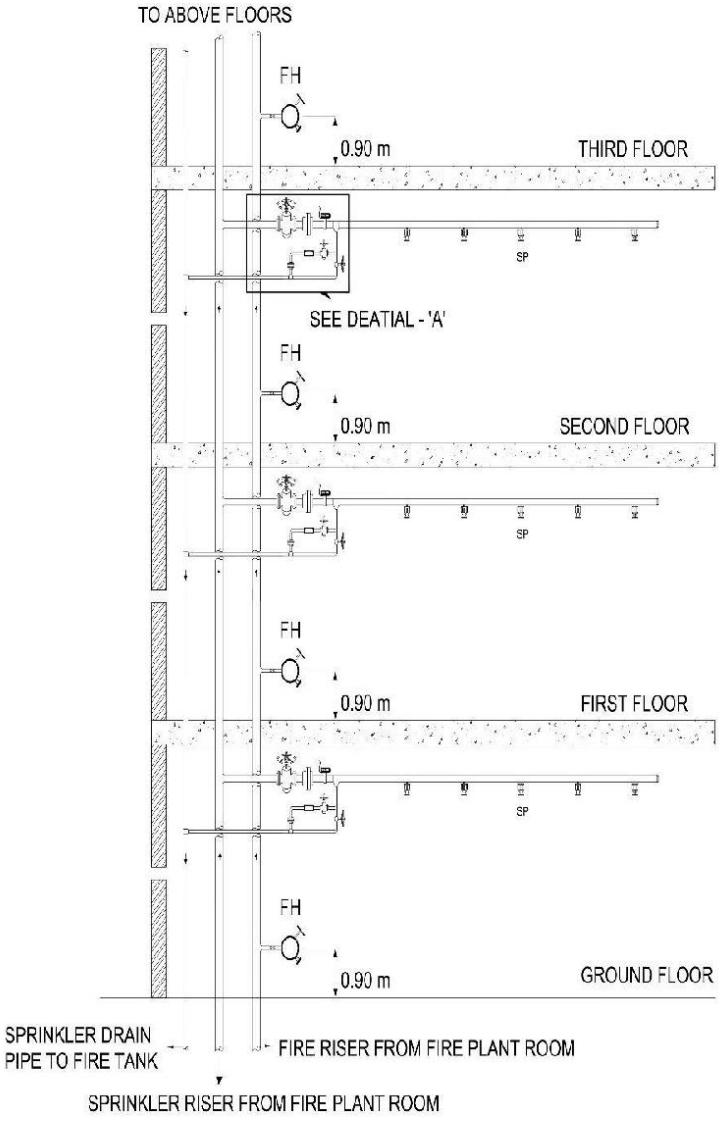
LEGEND

F-1	ELECTRICAL FIRE PUMP
F-2	DIESEL DRIVEN FIRE PUMP
F-3	JOCKEY PUMP
PV	PRESSURE VESSEL
FH	FIRE HYDRANT
	VALVE
	FLEXIBLE CONNECTION
	NON-RETURN VALVE
	SPRINKLER



TYPICAL SYSTEM OF PUMPING WITH ONE ELECTRIC, ONE DIESEL FIRE PUMP

FIG.3



ELEVATIONAL VIEW

LEGEND

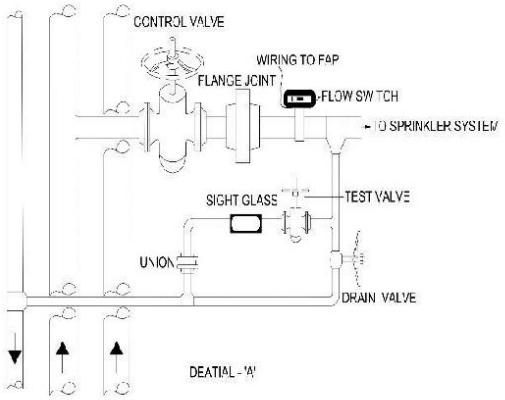
F-1	DIESEL DRIVEN FIRE PUMP
F-2	EL. HYDRANT FIRE PUMP
F-3	JOCKEY PUMP
F-4	EL. SPRINKLER PUMP
PV	PRESSURE VESSEL
FH	FIRE HYDRANT
FAP	FIRE ALARM PANEL
SP	SPRINKLER

VALVE

FLEXIBLE CONNECTION

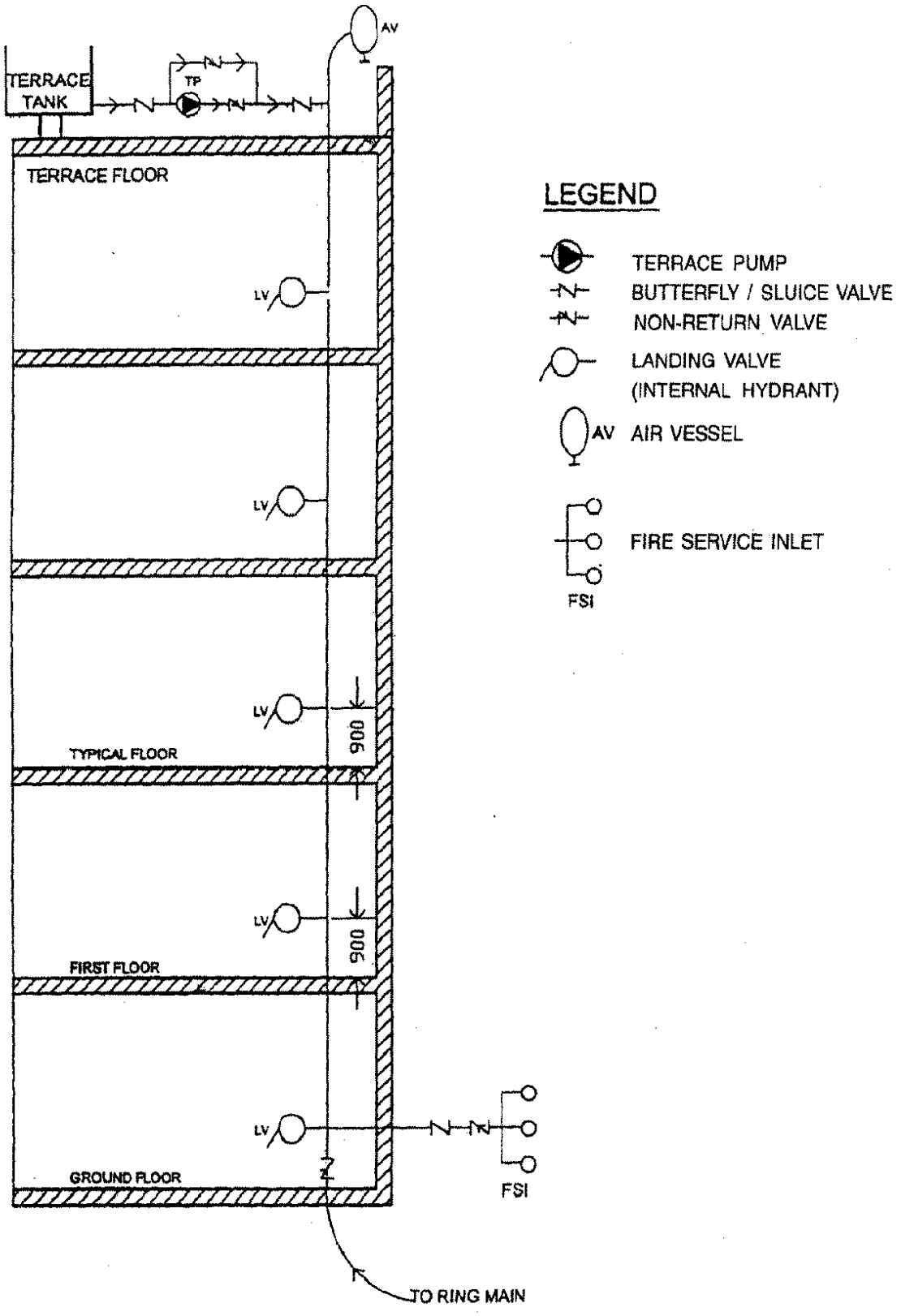
NON-RETURN VALVE

SPRINKLER

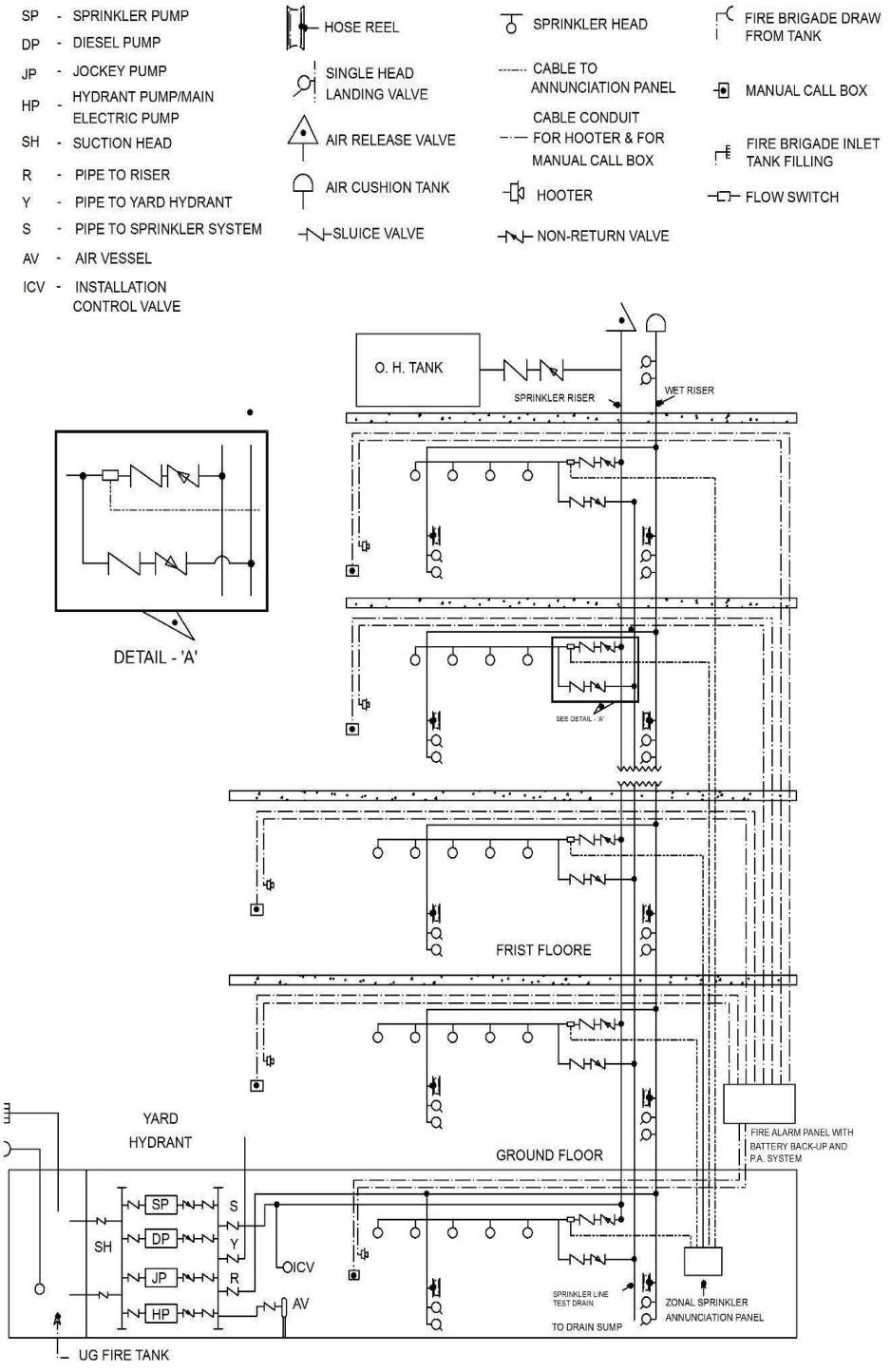


TYPICAL SYSTEM OF PUMPING WITH TWO ELECTRIC, ONE DIESEL FIRE PUMP

FIG.4

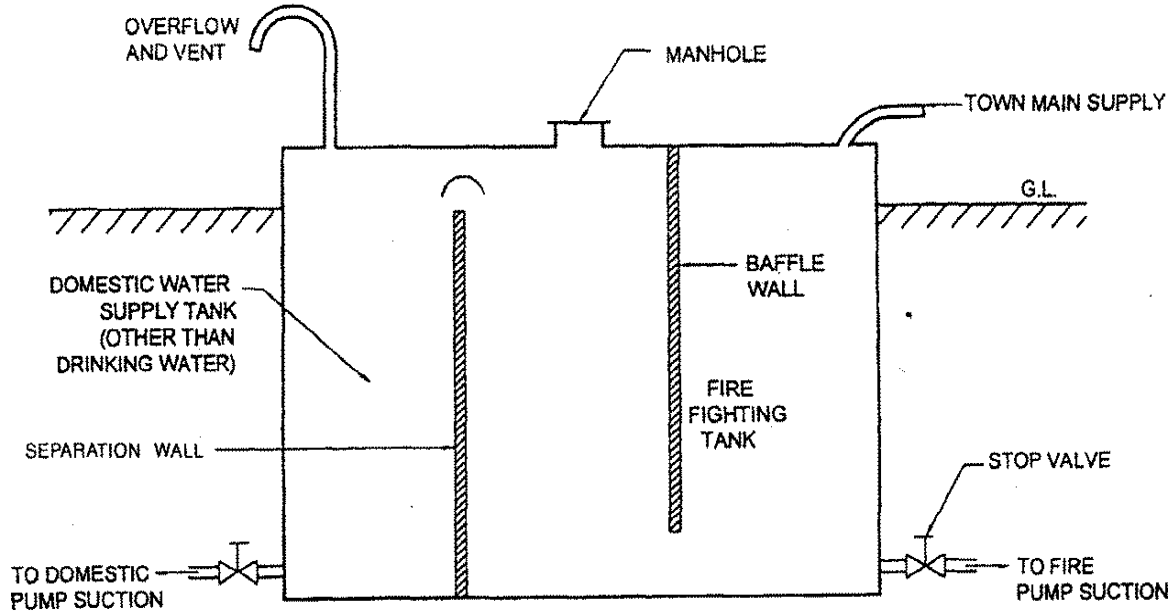


TYPICAL ARRANGEMENT OF DOWN COMER SYSTEM
Fig. 5



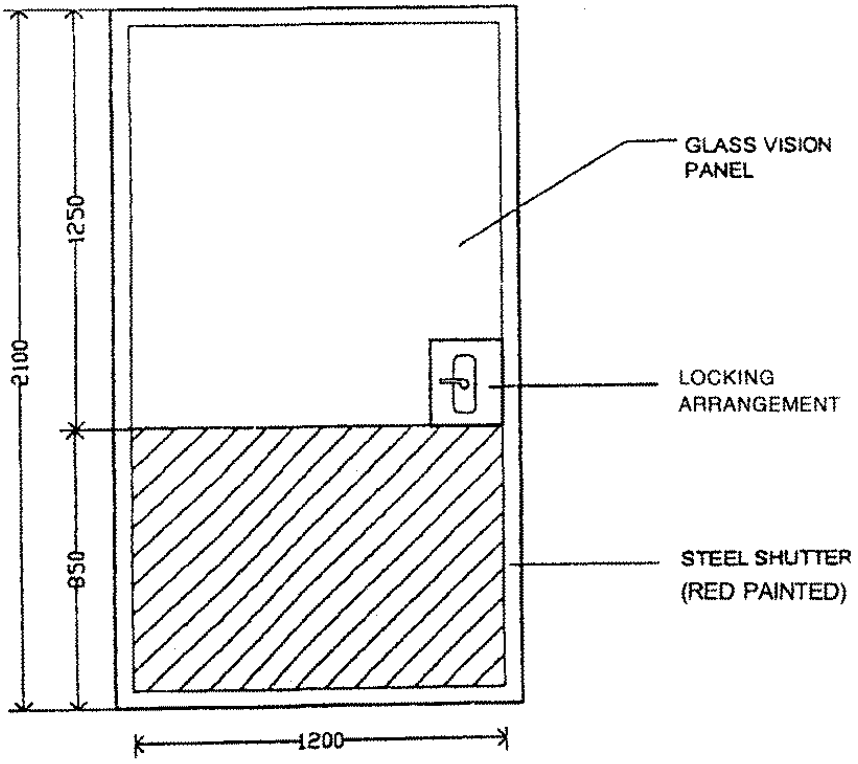
TYPICAL ARRANGEMENT OF WET RISER AND TOTAL SPRINKLER SYSTEM OF BUILDING

FIG. 6

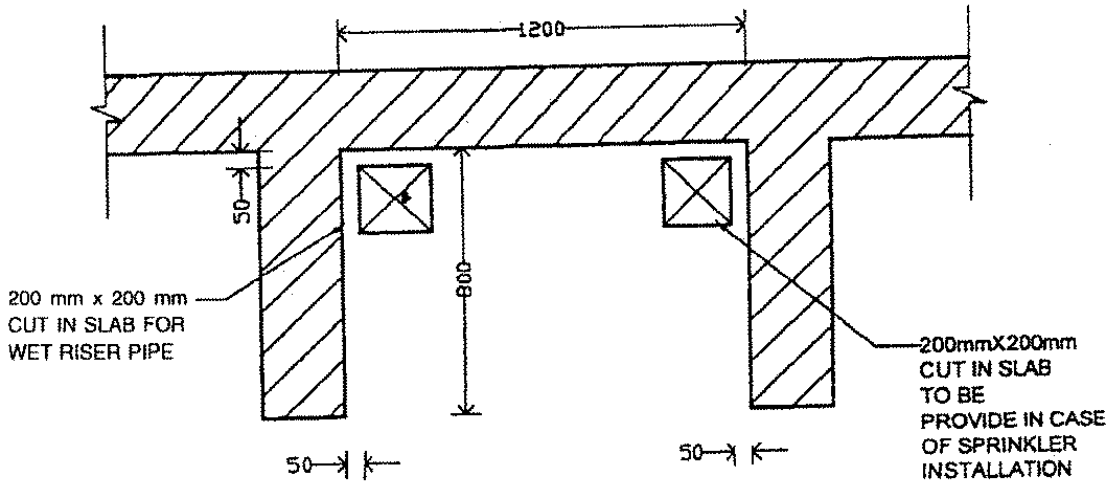


TYPICAL ARRANGEMENT FOR PROVIDING COMBINED FIRE FIGHTING AND DOMESTIC WATER STORAGE TANK

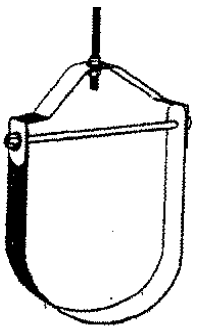
Fig. 7



WET RISER SHAFT DOOR DETAILS

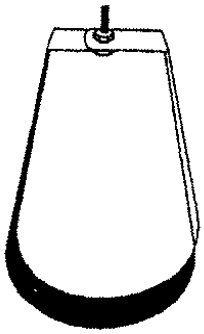


WET RISER SHAFT
Fig. 8

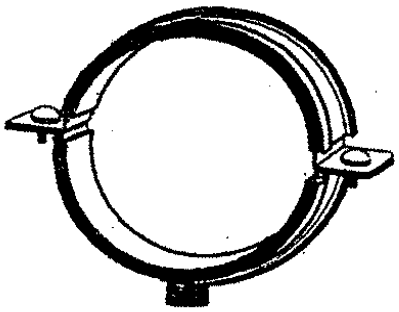


CLEVIS HANGERS

Heavy duty
clevis hangers with
pendulum movement
to adjust varying heights

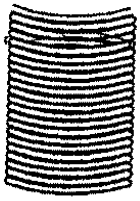


SPRINKLER HANGERS



PIPE SUPPORT SPLIT CLAMP

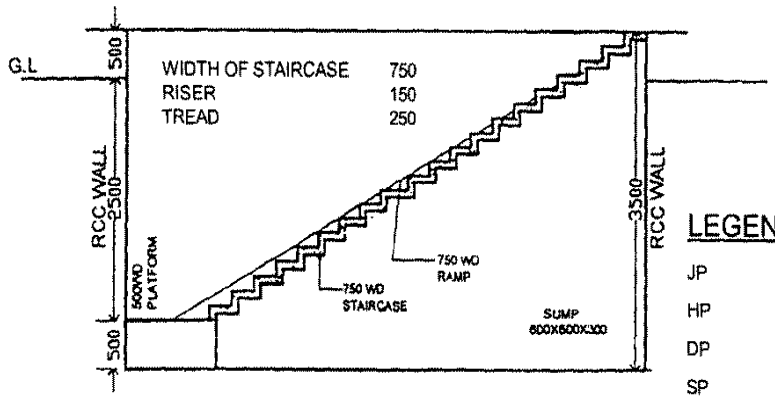
split pipe support
clamps for vertical,
horizontal &
roof hanging
installation



FULL THREADED RODS

in sizes
8 mm
10 mm
12 mm

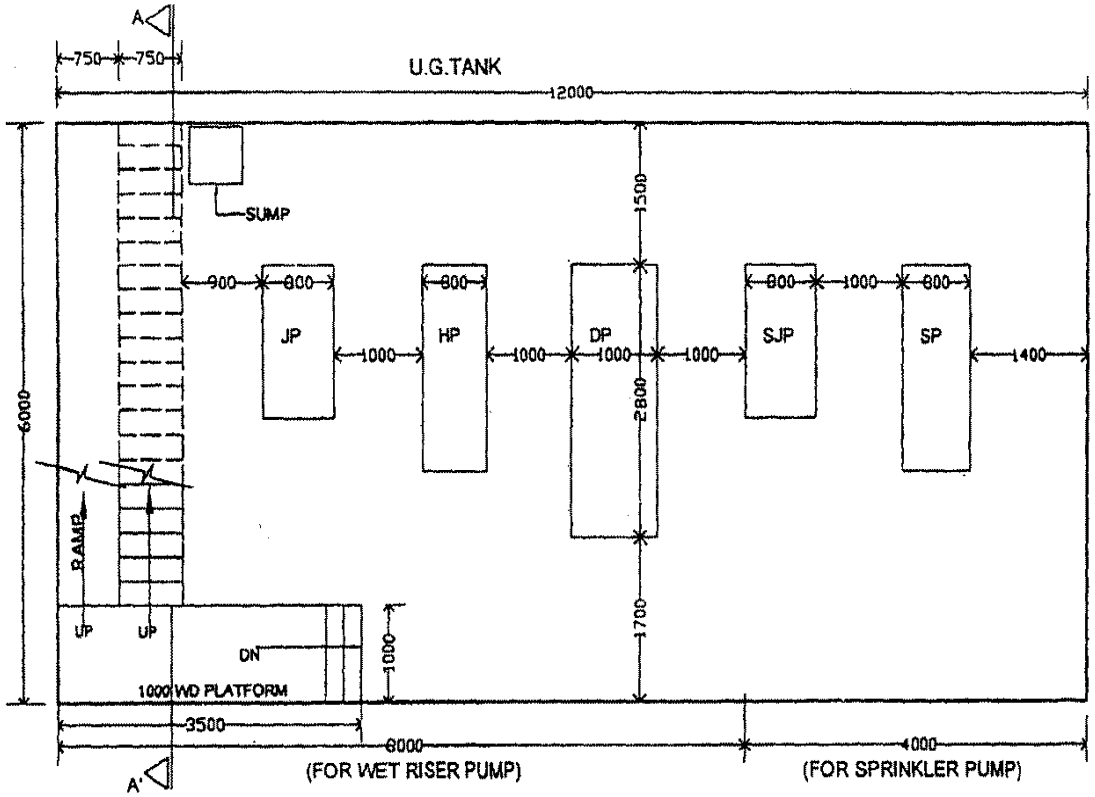
TYPICAL PIPE SUPPORT
Fig. 9



SECTION THRU AA'

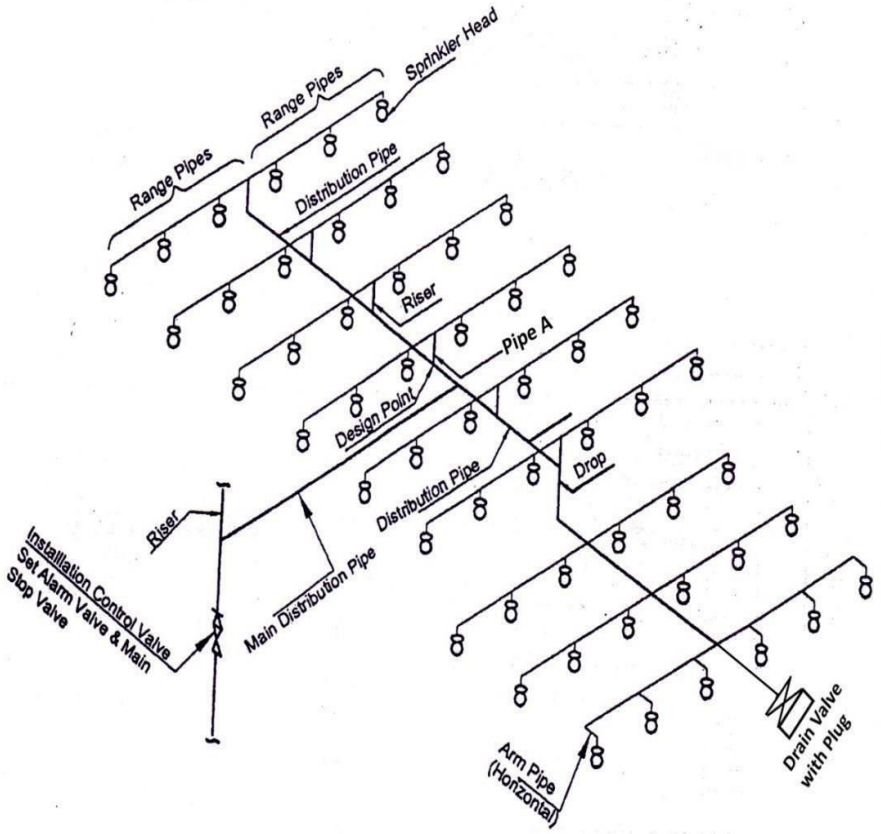
LEGENDS

JP	:	JOCKY PUMP
HP	:	HYDRANT PUMP
DP	:	DIESEL PUMP
SP	:	SPRINKLER PUMP
SJP	:	SPRINKLER JOCKY PUMI

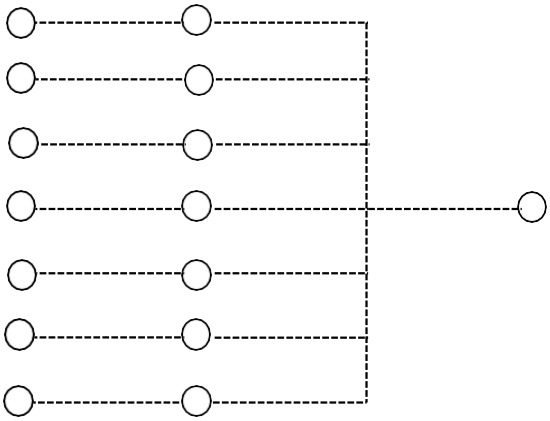


PLAN

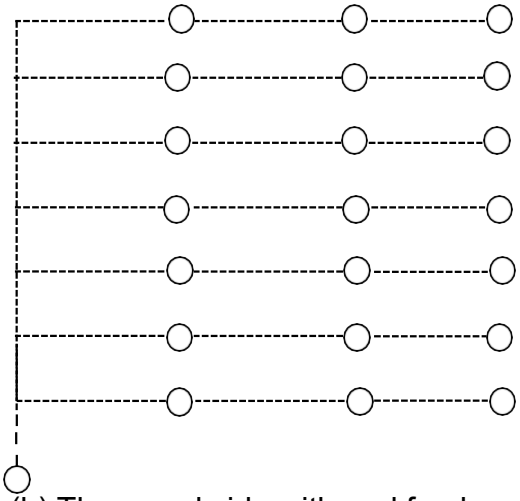
LAYOUT OF FIRE PUMP HOUSE WITH SPRINKLER PUMP
Fig. 10



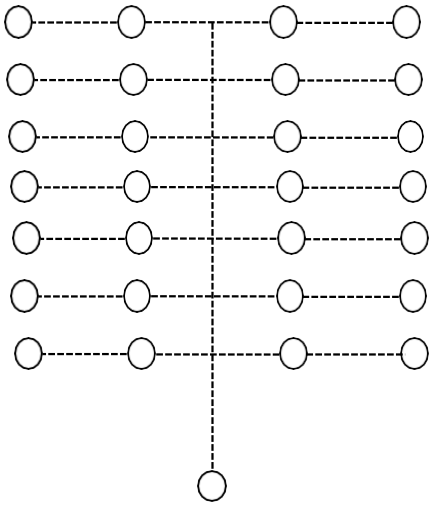
TYPICAL LAYOUT OF SPRINKLER INSTALLATION
Fig. 11



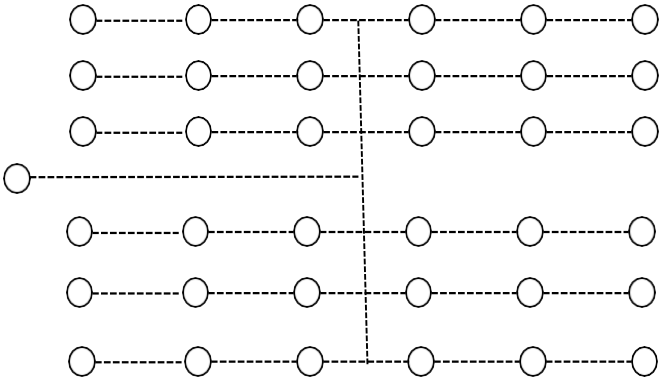
Two end side with central feed



(b) Three end side with end feed

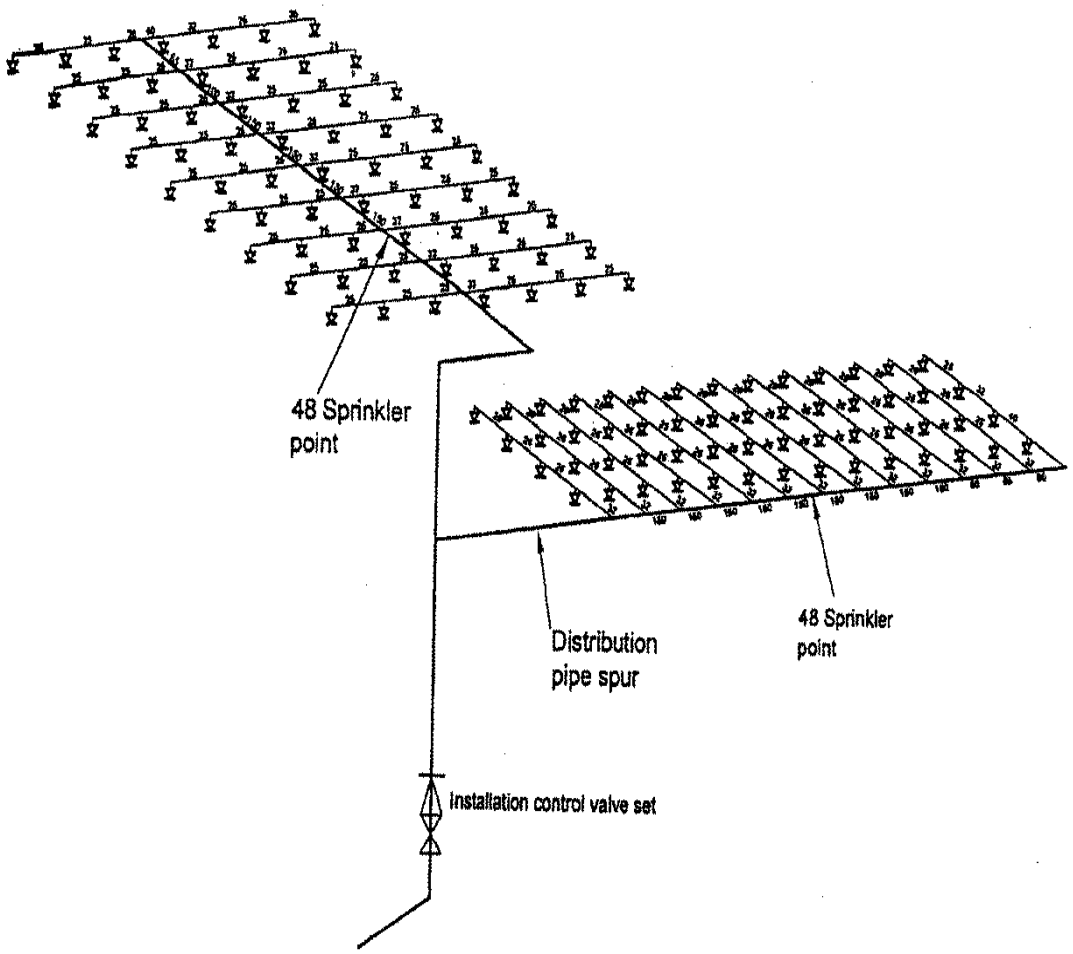


(c) Two end centre with end feed

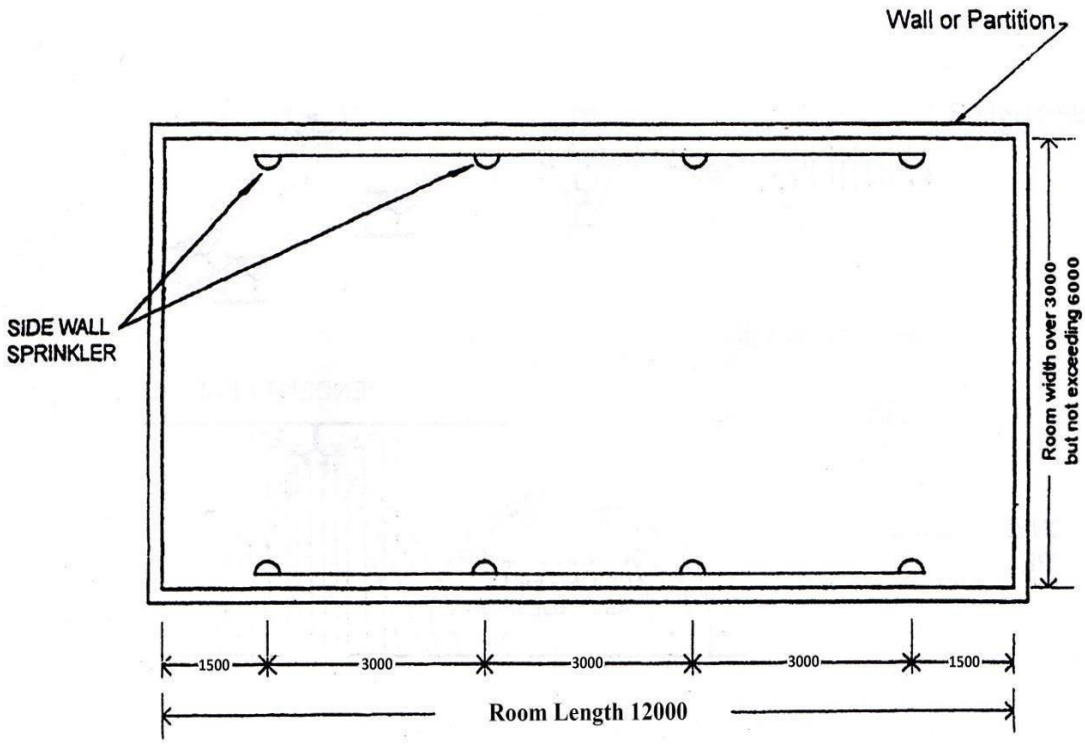


(d) Three end centre with central feed

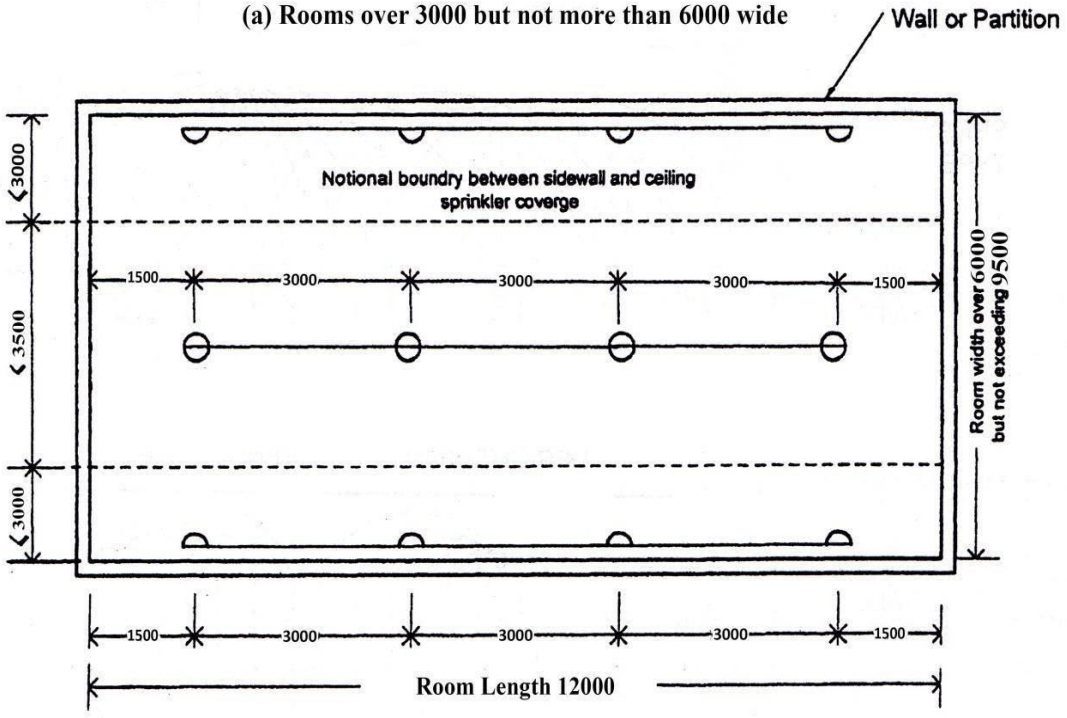
TYPICAL LAOUT OF CONNECTION OF SPRINKLERS
Fig. 12



TYPICAL PIPE SIZING FOR SPRINKLER INSTALLATION
Fig. 13

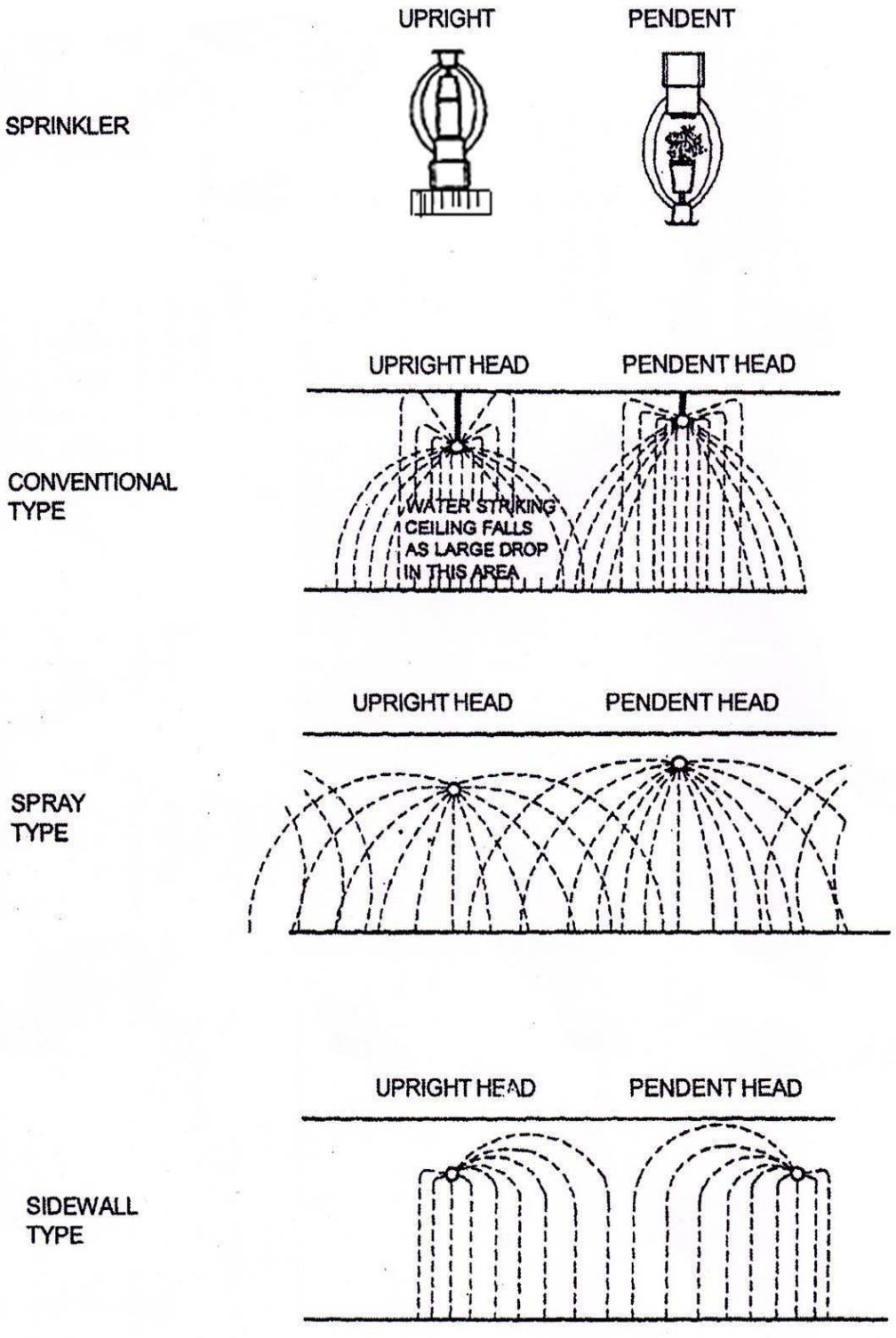


(a) Rooms over 3000 but not more than 6000 wide



(b) Rooms more than 6000 but not more than 9500 wide
(All dimensions are shown in millimetres)

SIDEWALL SPRINKLER SPACING
Fig. 14



TYPE OF SPRINKLER
Fig. 15



भारत सरकार

GOVERNMENT OF INDIA

परमाणु ऊर्जा विभाग

DEPARTMENT OF ATOMIC ENERGY

निर्माण, सेवा एवं संपदा प्रबंधन निदेशालय

DIRECTORATE OF CONSTRUCTION, SERVICES AND ESTATE MANAGEMENT