LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

LODHA CLARIANT

TENDER SPECIFICATION

FOR

PLOT C SALES GALLERY

BH-ZSG-SPE-M-0001

INTERNAL HVAC SERVICES

00	Nov 2015	Tender	TA	KJ	LODHA
Rev	Date	Issue	Prepared by	Checked by	Client

INDEX- PLOT C SALES GALLERY

VOLUME	SECTION	DESCRIPTION
VOLUME 01	A	GENERAL
VOULME 02	B	TECHNICAL SPECIFICATION – HVAC SYSTEM
	C & D	EQUIPMENT SCHEDULE
	E	SCHEDULE OF DEVIATIONS FROM TECHNICAL SPECIFICATION
	F	SCHEDULE OF DEVIATIONS FROM GENERAL & SPECIAL CONDITIONS OF CONTRACT, BOQ/SCHEDULE OF PRICES
	G	LIST OF APPROVED MAKES
VOLUME 03	H	PREAMBLE TO BILL OF QUANTITY/SCHDULE OF PRICES
	I	BILL OF QUANTITY (BOQ)
	J	LIST OF DRAWINGS
	K	SCOPE OF DRAWINGS

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – A

GENERAL CONDITIONS OF CONTRACT

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

1.1 SUMMARY

A. This Section includes technical specifications for Lodha Kolshet Plot C Sales Gallery Internal HVAC System.

B. The entire work shall be carried out in a manner consistent with good engineering practice. The Contractor shall take into account all site conditions including space allocation for HVAC System while designing the system and selecting the equipment.

C. The Contractor shall be responsible for engaging a qualified, competent and experienced HVAC System specialist to perform the system design verification, preparation and submission of system proposal, obtaining approvals from relevant authorities and site supervision for installation, testing and commissioning.

D. The Contractor shall perform the system design verification based on the criteria / data and technical requirements specified in this section / drawings and the local Authorities regulations / requirements.

E. The Contractor shall provide system which comprises products of manufacturers who have designed, developed and used these products successfully for a period of at least for last five years.

F. The Contractor shall submit catalogue information, design calculations and samples complete with full technical data and shop drawings for the entire system, test certificates, etc. and any other information required by client consultant for acceptance prior to commencement of installation.

G. The contractor shall provide the Air Conditioning system which can be interfaced with Home automation system.

1.3 CO-ORDINATION

A. Work shall be carried out in conformity with the specifications and accompanying drawings after approval by the Interior Designer/Consultant. The Contractor shall be responsible for taking actual measurements at site and varying the work in detail if required to meet the site conditions. Such deviations shall, however, be subject to the approval of the Employers Representative's.

B. The Contractor shall also co-operate with the Employers Representative's other Contractors, compare and coordinate drawings, specifications and time schedules and so arrange his work that there will be no interferences .The Contractor shall forward to the Employers Representative's copies of all correspondence and drawings so exchanged. Failure to check plans and conditions will render the Contractor responsible for bearing the cost of any subsequent change found necessary.

C. HVAC contractor is responsible for providing input in preparation of co-ordinated services layout for each apartment.

D. The contractor shall be required to do the part / complete installation work in phases so as to take maximum advantage of the work front as and when it gets available.

1.4 SYSTEM PERFORMANCE GUARANTEE

A. The contractor shall carry out the work in accordance with the Approved shop drawings, Specifications, Schedule of Quantities and other documents forming part of the Contract.

B. The contractor shall be fully responsible for the performance of the selected equipment (installed by him) at the specified parameters and for the efficiency of the installation to deliver the required end result.

C. The contractor shall guarantee that the HVAC system as installed shall maintain the inside conditions in the air-conditioned spaces as described under "Basis of Design" in the specifications

Copyright © Buro Happold Limited

D. The contractor shall also guarantee that the performance of various equipments individually, shall not be less than the quoted capacity; also actual power consumption shall not exceed the quoted rating, during testing and commissioning, handing over and guarantee period.

E. The contractor shall verify the AC load computed by consultant. For this, the contractor shall obtain the latest design basis from the Owner (i.e. lighting load, equipment load, latest architectural & interior plans and occupancy) to cross-check and calculate the capacity of various equipments.

1.5 SYSTEM UPTIME GUARANTEE

A. The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the Defects Liability period shall get extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period, the contract for Operation and Maintenance shall get extended by a month for every month having the shortfall and no reimbursement shall be made for the extended period.

B. The Contractor shall provide log in the form of CD and bound printed comprehensive log book containing tables for daily record of all temperatures, pressures, humidity, and power consumption. Starting and stopping times for various equipments, daily services rendered for the system alarms, maintenance and record of unusual observations etc. Contractor shall also submit preventive maintenance schedule.

C. Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the Owner's site representatives/Consultant's review. This shall include the type of service planned to be offered during Defects Liability Period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the Management.

D. The tenderer shall include a list of other projects where such an Operation Assistance has been provided.

1.6 ELECTRIC SUPPLY

A. Three phase electric supply will be 415 V. 50 Hz, 4 wires.

B. Single phase electric supply will be 240 V, 50 Hz, 3 wires.

1.7 INSTRUCTION TO TENDERER/ BIDDER

A. The Bidder / Tenderer shall furnish all the information called for in the all the sections of this contract, failing which the bid will be treated as incomplete and the Employers Representative's reserves the right to reject the bid. The Tenderer is advised to fill information strictly in the format enclosed.

B. The Bidder shall carefully study all sections and drawings enclosed (if any) with specification and indicate deviations in the relevant Sections of the Specification. If no deviations are stated it will be assumed that the offer conforms in all respects to the specification and the Employers Representative's reserves the right to evaluate the Bid as such without further reference to the Bidder.

C. The Bidder is also advised to have discussion with Employers Representative's before preparing the Bid and bring out clearly in the Bid any discrepancies found in the tender package or any items which in his opinion have not been included in the tender package but is required for the completion of the project.

D. The Bidder must obtain for himself on his own responsibility and at his own expense all the information's which may be necessary for the purpose of making a tender and for entering it into a contract and must examine the drawings, inspect the site of the work and acquaint himself with all local conditions means of access to the work, nature of the work and all matters appertaining thereto.

E. Time allowed for carrying out the work as mentioned in the Memorandum shall be strictly observed by the Contractor and it shall be reckoned from the day written order to commence the work is issued. The work shall throughout the stipulated period of the contract be proceeded with all due diligence and if the contractor fails to complete the work within the

Copyright © Buro Happold Limited

specified period he shall be liable to pay compensation as defined in the General Conditions of Contract. The Bidder shall before commencing work prepare a detailed work programme which shall be approved by the consultants and the Employers Representative's.

F. Each Bidder shall submit in his bid a list of large works of a like nature he has executed giving details as to their magnitude and cost, the proportion of work done by the Contractor in it and the time within which the works were completed, the Bidder shall also submit along with his bid a list mentioning the names of manufacturers of specialised items.

G. The successful Bidder is bound to carry out any item of work necessary for the completion of the job even though such items are not included in the quantities and rates. Schedule of instructions in respect of such additional items and their quantities will be issued in writing by the Consultants with the prior consent in writing to the Employers Representative's.

1.8 QUALITY ASSURANCE AND QUALITY CONTROL

A. The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. Quality standards prescribed shall form the backbone for the quality assurance and quality control system.

B. Following plans shall be prepared and submitted to Employers Representative's within 30 days after award of the contract

   a. Quality Plan to be submitted for approval.

   b. QA/QC Procedure and Inspection Test Plan.

   c. Material inspection report. (all incoming material)

   d. Work Inspection Report (Installation inspection)

   e. Area Clearance and handing over formats.

   f. QA/QC team structure.

C. At the site level the Contractor shall arrange the materials, their stacking/ storage in appropriate manner to ensure the quality. Contractor shall provide equipment and manpower to test continuously the quality of materials, assemblies etc. as directed by the Engineer. The test shall be conducted continuously and the result of tests maintained. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of surface.

D. The Consultant shall be free to carry out tests as may be considered necessary by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

E. The test shall be conducted at the site laboratory that may be established by Consultant or at any other Standard Laboratory selected by Consultant.

F. The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of Contractor failing to arrange transportation of the samples in proper time Consultant shall have them transported and recover two times the actual cost from the Contractor's bills.

1.9 EXTENT OF SERVICE

A. Works to be carried out under this Contract is the design verification, shop drawing, selection, manufacture, supply, installation, testing and commissioning of the Apartment HVAC System and associated installation to comply with the requirements from any authorities having jurisdiction over the said system and installation and the requirements on performance, materials and equipment as stipulated in the Technical Specifications.

B. Contractor's attention is drawn specially to the space / area limitation shown on the drawings for compliance.

C. Contractor shall also note the limitation of equipment access as shown on the drawings and shall ensure that all equipment can be safely transferred to the planned space. Contractor

Copyright © Buro Happold Limited

shall include in scope if necessary the work for dismantling and reassembly / assembly of the equipment to accommodate any access restriction.

D. Clearing away rubbish.

E. Tools, Tackles, Scaffolding including the provision, maintenance and removal of any special scaffolding as required.

F. Unloading, distribution and placing in position all plant, machinery, etc.

G. Coordination of the other services entering in your work front.

H. Cutting chases for pipes and the like in walls, floors, partitions etc (except on structural members) and the like and subsequent making good.

I. Cutting or forming holes for pipes, ducts and the like through walls, floors, partitions, roofs and the like (except Structural members), subsequent making good and providing sleeves and/or sub-frames as required.

J. Pinning ends of supports for pipes, equipment, appliances, fittings and the like to wall, floors, partitions, soffits etc and making good.

K. Leaving mortices, sinking and the like for holding down bolts, brackets, supports and the like and grouting in.

L. Filling around, boring holes through and making good of finishing up to pipes, supports, brackets and the like.

M. Building of the meter pits, access chambers and sump pits and parking drains.

N. Application of Paint on exposed pipe work, fittings, equipment and the similar items with Rust proof paint.

O. Concrete equipment bases, pipe supports, plinths, suspended slabs, steel support beams and the like, together with all necessary waterproofing, sound attenuation, and the like as required.

P. All Structural (Metallic / Non-metallic) requirements for the installation of the System to be complete and will be in the scope of the contractor.

Q. The contractor must bear in mind that all the work shall be carried out strictly in accordance with the approved specifications and approved working drawings as instructed by the Employers Representative's and also in compliance with the local public authorities and to the requirements of any acts, rules and regulations. No deviation on any account will be permitted.

R. Any other Minor civil work pertaining to main work

S. Getting all approvals as required from Statutory / Local authorities required during construction and till commissioning and handing over the entire fire fighting system.

T. Electrical works from and including control panel, inside the HVAC system plant room.

1.10 WORKS BY OTHERS

Following works will be excluded from this Contract and shall be carried out by other Agencies:

A. All Major civil works such as R.C.C. tanks, opening on structures.
B. Electrical supply to work front. The Employer does not guarantee continuous supply of Power and no compensation whatsoever shall be allowed for supply becoming intermittent or for break downs in contractors Equipment's.
C. Ventilation and general lighting for the plant room during construction.
D. False ceiling work as shown on the Interior Designer's/Consultant's drawings.
E. Electricity and water as required for the erection, testing and commissioning free of charges.
F. Electrical Supply will be provided till the control panel inside the plant room.

1.11 DRAWINGS AND LITERATURE

A. List of Equipment/ Materials:

Copyright © Buro Happold Limited

B. The Following submittals shall be included with the tenders. Failure to provide the required information may cause rejection of the tender. Detailed equipment list, identifying types, models, and all materials & equipment proposed. This submittal shall include manufacturer's data sheets showing the types and models of all equipment and materials. The submittals shall be in the format given in relevant sections of tender documents.

C. When a data sheet shows more than one make, the proposed make shall be clearly indicated by arrows or other suitable means.

D. The data shall be submitted in a ring binder, indexed by product.

E. The data shall not include superfluous cut sheets (i.e., unedited manufacturer's catalogues are not acceptable).

F. Shop Drawings / Technical Data:
   1. After the award of work, the Contractor shall submit shop drawings including Builders Work Drawings and technical data for approval. Shop drawings and technical submittals shall include sufficient data to indicate complete compliance with Specification, Contract Documents and System Requirements. Submissions shall be in the form of drawings, brochures, catalogues and/or narrative descriptions with certified standards.
   2. The tender drawings represent the design intent and a feasible scheme / layout that may be re-arranged in the space allocated during the shop drawing preparation subjected to prior approval by the Architect/ Consultant before the actual shop drawing and execution.
   3. After the award of work, all changes in architectural, structural, interior design, facilities planning or any decision of Employers Representative's / Architect / Consultant causes redesign of the system, the contractor shall carry out the same in shop drawings and calculations and get approval from the Consultant. Consultants will advise / guide the Contractor to carry out such changes but will not provide any drawing further to the tender drawings, issued with these documents.
   4. Approval by the Employers Representative's/ Architect/ Consultant of the Technical Submittals and drawings shall not relieve the contractor of any part of his obligation to meet all the requirements of the Contract or of the correctness of his drawings. The Contractor shall be responsible for and pay for all alterations of the works due to discrepancies or omissions in the drawings or other particulars supplied by him, whether such drawings have been approved by the Employers Representative's/ Architect/ Consultant or not.

G. As-Built Drawings:
   1. A separate set of approved shop drawings corrected to indicate the as-built conditions shall be kept at the site. These drawings shall be maintained in a current condition at all times and shall be made available for review upon request. All variations from the approved shop drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials and/or required coordination between other Contractors shall be indicated in sufficient detail to accurately reflect the as-built conditions.
   2. Upon completion of the work, before final payment, one complete Master set and two additional blue-line sets of As-built drawings shall be submitted for approval, which shall include plans, sections, specific details, schematic diagrams, riser diagrams, control diagrams and any other drawing as directed by the Employers Representative's.
   3. Contractor shall submit As-built drawings on DVD in addition to the above. All drawings shall be made on Auto CAD.

H. Quality Control Submittals:
   1. Proof of compliance to applicable codes and standards.
   2. Final commissioning and testing reports.

I. Operation and Maintenance (O & M) Manuals : Shall be as described in scope o work document.

J. Operation and Maintenance (O & M) Manuals :
   1. Submit two (2) draft copies of O & M manuals for review. After review by Employers Representative's representative, the Contractor shall incorporate review comments and submit Six (6) final copies.

Copyright © Buro Happold Limited

2. During guarantee period, the Contractor shall update the manuals with modifications made to system, providing replacement pages or supplements in quantity stated above.
3. O & M manuals shall be assembled into multi-volume sets as necessary and required by the Employers Representative's.
4. Each volume shall be protected with a heavy duty vinyl plastic binder. Volumes shall have plastic printed dividers between major sections and shall have oversized binders to accommodate up to 20 mm thick set of additional information.
5. Each binder shall be silk screened with project name and volume title on front cover and binder.
6. First page of each manual shall be identified with project name, manual title, Employers Representative's name, Consultant's name, address and service phone number and person who prepared the manual.
7. Operating and maintenance Manual shall serve as training and reference manual for all aspects of day-to-day operation of the system, such as:
   - Step by step direction.
   - Provision of alarms and their sequences.
   - Do's and Don'ts in operation.
   - Fault location and remedy chart.
   - Schedule of spares.

1.12 TESTING:

A. All equipment and the whole system shall be tested as required by the various sections of the specifications and test data as required shall be furnished.

B. Routine tests for the various items of equipment shall be performed at the Contractor's works and relevant test certificates to be furnished. If required by the Employers Representative's, have the Contractor shall permit the Employers Representative's authorised representative to be present during any of the tests. After notification of the Employers Representative's that installation has been virtually completed, the Contractor shall conduct under the direction and in the presence of the Employers Representative's, such tests and inspection as been specified or as the Employers Representative's shall consider necessary to determine whether or not the full intent of the Requirements of the drawings and specifications have been fulfilled. In case the work does not meet the full intent of the specifications and further tests considered necessary, the Contractor shall conduct such tests and bear the expenses thereof.

C. Contractor shall operate, test and adjust all systems equipment, pumps, motors, Control equipment, other electrical equipment provided in connection with this installation and shall make all necessary adjustments and corrections to establish the specified system / equipment capacity at given designed condition.

D. All equipment and systems shall be tested after installation and test readings submitted as specified.

1.13 REJECTION OF DEFECTIVE EQUIPMENT

A. If the completed system installation or any portion thereof, before it is taken over or during the guarantee and defects liability period, be found defective or fails to fulfil the intent of these specifications, the Contractor shall on receipt of notice from the Employers Representative's forth with dismantle and replace the defective equipment/ material/ system installations.

B. Should he fail to do so within 15 days of intimation by the Employers Representative's, the Employers Representative's may reject and replace at the risk and expense of the Contractor the whole or any portion of the equipment/ material/ system installations found defective or fails to fulfil the requirements of the Contract.

C. The Employers Representative's shall have the right to operate all equipment/ System/ Installation in operating condition whether or not such equipment/ system/ installation have been accepted as complete and satisfactory. Repairs and alterations shall be made at such times and as directed by the Employers Representative's.

1.14 SAFETY CODE

Copyright © Buro Happold Limited

A. There shall be maintained in a readily accessible place first-aid appliances including adequate supply of sterilized dressing and cotton wool.

B. The injured person shall be taken to a public hospital without loss of time.

C. Suitable and strong scaffolds should be provided for workmen for all works that cannot be done safely from the ground.

D. No portable single ladder shall be over 8 metres in length. The width between the side rails shall not be less than 30 cm (clear) and the distance between the two adjacent rungs shall not be more than 30 cm. When a ladder is used an extra mazdoor (labour) shall be engaged for holding the ladder.

E. Every opening in a floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing whose minimum height shall be one metre.

F. No floor, roof or other part of the structure shall be as over-loaded with debris or materials as to render it unsafe. Workers employed on mixing and handling material such as asphalt, cement mortar, concrete or lime mortar shall be provided with protective footwear and hand-gloves.

G. Protective gear such as safety helmets, boots, belts, etc. shall be provided by the Contractor at his own cost to all his manpower at site. The Contractor shall impose such requirements on all Sub-Contractors also. It shall be the responsibility of the Contractor to ensure that such protective gear is worn at all times by all personnel working at site. The Project Manager/ Engineer shall have the right to stop any person not wearing such protective gear from working on the site.

H. Those engaged in welding works shall be provided with welder's protective eye-shields and gloves. Fire extinguishers must be provided during welding at all times.

I. No paint containing lead or lead products shall be used except in the form of paste or readymade paint.

J. Suitable facemasks should be supplied for use by the workers when the paint is applied in the form of spray or surface having lead paint dry rubbed and scrapped.

K. Overalls shall be supplied by the Contractor to the painters and adequate facilities shall be provided to enable the working painters to wash during the cessation of work.

L. In case the Contractor fails to make arrangements and provide necessary facilities as aforesaid, the Employers Representative's shall be entitled to do so and recover the costs thereof from the Contractor. The decision of the Employers Representative's in this regard shall be final and binding on the Contractor.

M. Use of hoisting machines and tackle including their attachments, anchorage and supports shall be in perfect condition.

N. The ropes used in hoisting or lowering material or as a means of suspension shall be durable and in perfect condition.

O. All electrical connections for construction activity shall be taken through proper receptacles only. No loose wire connections shall be allowed.

1.15 CONTRACTOR'S REPRESENTATIVES

A. The Contractor shall employ qualified representatives on full time basis (and shall be available at site) whose name shall have previously been communicated in writing to the Employers Representative's and approved by them to supervise the execution. Any written order or instruction given to the representative shall be deemed to have been given to the Contractor.

B. The Employers Representative's shall be at liberty to object to any particular representative or any persons employed by the Contractor on the work and the Contractor shall remove the person objected to, on receipt from the Employers Representative's, in writing, a request requiring him to do so. The Contractor shall provide in his place another competent representative acceptable to the Consultants.

Copyright © Buro Happold Limited

1.16 CONTRACTOR AGREEMENT - Contractor shall be responsible to read and agree the scope of work as detailed in SOW, GCC & PCC documents.

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – B

TECHNICAL SPECIFICATIONS

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

PART 1 - GENERAL

1.1 HVAC SYSTEM DESCRIPTION

The mechanical systems for the sales gallery consists primarily of air conditioning system using Variable refrigerant Volume outdoor units with Ductable split / Hi-wall Split units as indoor units.

Toilets & Kitchens in the residential units would have exhaust fan.

1.2 BASIS OF DESIGN:

A. Standards

- AHRI 1230 : 2010 Performance rating of Variable refrigerant flow (VRF) multi split air conditioning and heat pump equipment.
- AHRI 365:2009 Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units
- AHRI 210/240:2008 Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
- AHRI 340/360:2007 Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment
- IS 11327:2007 Requirements for refrigerants condensing units
- IS 277:2003 Specification for galvanized steel sheets
- IS 655:2006 Air duct specification
- IS 5111:1993 /ISO 917:1989 Testing of refrigerant compressors
- IS 8148:2003 Packaged air conditioners (first revision)
- IS 660 Safety code for mechanical refrigeration
- IS 817 : 2005 Refrigerant designation system
- IS 1391 Part 2 Room air conditioners specification Part 2 Split air conditioners
- IS 7613:1975 Method of testing panel type air filters for air conditioning and ventilation purposes.
- ANSI/ASHRAE Standard 62.1–2010 “Ventilation for Acceptable Indoor Air Quality”
- ANSI/ASHRAE Standard 55–2010 “Thermal Environmental Conditions for Human Occupancy”
- ANSI/ASHRAE Standard 90.1–2010 “Energy Standard for Buildings Except Low-Rise Residential Buildings”
- ANSI/ASHRAE Standard 34–2010 “Designation and Safety Classification of Refrigerants”
- ANSI/ASHRAE Standard 15-2010 “Safety Standard for Refrigeration Systems
- Electrical motors, cables, wiring and accessories as per ECBC 2009.

Copyright © Buro Happold Limited

B. Guidelines

- Energy Conservation Building Code (ECBC 2009)
- Bureau of Energy Efficiency System Requirements (BEE)
- ISHRAE – Indian Society Of Heating Refrigeration And Air Conditioning Engineers
- ASHRAE Guideline 0–2005 “The Commissioning Process”
- ASHRAE Guideline 1.1-2007 “HVAC and Technical Requirements for The Commissioning Process”
- ASHRAE Guideline 5–1994 “Commissioning Smoke Management Systems”
- ASHRAE Guideline 12-2000 “Minimizing the Risk of Legionellosis Associated with Building Water Systems”
- ASHRAE Guideline 13-2007 “Specifying Direct Digital Control Systems”
- ASHRAE Guideline 14-2002 “Measurement of Energy and Demand Savings”
- ASHRAE Guideline 16-2010 “Selecting Outdoor, Return and Relief Dampers for Air-Side Economizer Systems”
- SMACNA – Installation standards for HVAC systems
- Chartered Institute of Building Services Engineers (CIBSE) guidance
- AHRI – Air Conditioning, Heating & Refrigeration Institute
- AMCA – Air Movement Contractors Association
- ASME – American Society of Mechanical Engineers
- ASTM – American Society for Testing and Materials Ambient Conditions.

Copyright © Buro Happold Limited

C. Geographic Location

1. Site location.: Mumbai
2. Geographic bearing : 19.12 Deg 30'N
3. Altitude : 14 Meters above mean sea level

D. Outdoor Design Conditions

The outdoor design conditions have been considered as follows.

Cooling DB/MCWB @ 0.4 %	**35.9 deg C DB**	**22.7 deg C WB**
Cooling WB/MCDB @ 0.4 %	**31.2 deg C DB**	**27.7 deg C WB**
Heating DB/MCWB @ 99.6%	**16.5 deg C DB**	**13.9 deg C WB**

E. Design Parameters

Centrifugal/ Axial Fans

Maximum fan outlet velocity for Fans up to 450 mm dia.	9 m/s
Maximum fan outlet velocity for Fans above 450 mm dia.	10 m/s
Maximum fan speed for fans up to 450 mm dia.	1450 RPM
Maximum fan speed for fans above 450 mm dia.	1000 RPM.

Cabinet type Centrifugal backward fans

Maximum face velocity across MERV 4 filters	2.5 m/s
Maximum fan outlet velocity :	9 m/s
Maximum fan speed :	
a. Fan above 300 mm dia :	900 RPM
b. Fans upto and including 300 mm dia :	1440 RPM
Maximum fan motor speed :	1450 RPM

END OF PART 1

Copyright © Buro Happold Limited

PART-2 EQUIPMENT AND PRODUCT SPECIFICATION

2.1 EQUIPMENTS

A. Variable Refrigerant Flow (VRF) / Variable Refrigerant Volume (VRV) System

1. Scope:

   Scope of this section comprises the supply, installation, testing and commissioning of VRF/VRV. system as follows :

   a. Indoor units with mounting brackets/supports.
   b. Air-cooled condensing units with outdoor support structure. Outdoor support structure shall be painted with 2 coats of epoxy primer and 2 coats of epoxy paint.
   c. All indoor unit shall have anticorrosive coating and outdoor unit shall have blygold coating.
   d. Fan motor, evaporator motor interlock local isolators for motors.
   e. Hard copper refrigerant piping between outdoor and indoor units as specified elsewhere.
   f. Electrical panels with starters etc., for compressors motors, condenser fan motor and evaporator fan motors.
   g. Digital thermostats and safety controls.
   h. Single phase preventors.
   i. Installation accessories, mounting brackets, filters, drier etc.
   j. First charge of refrigerant gas and oil.
   k. Ducting with insulation and air terminal devices as specified elsewhere.
   l. Drain piping for evaporator units.
   m. Insulation of indoor unit, refrigerant piping and drain piping.
   n. Electrical wiring from isolator power supply provided by others, within 3 Meters away from the outdoor units.
   o. Testing and commissioning.
   p. For detail specification of indoor and outdoor unit refer to point no. G and H
   q. The Contractor shall carry out CFD analysis for the complete proposed installation and equipment shall be ordered based on the results of the analysis.
   r. Selected out door units shall have sufficient static to discharge the hot air against the wind resistance.
   s. All indoor units shall have flexibility for LHS/RHS coil connections. The Contractor to confirm the coil connections with employer's representative before ordering the equipment.

   The Bidder shall submit the technical data sheets as published by manufacturer along with the tender.

2. Materials and Construction:

   The system selected shall be a modular with multiple compressors in each module, with number of indoor units connected to centrally located outdoor units. Outdoor units for all the systems shall be air cooled type and mounted externally..

   a. VRF/VRV air conditioners shall be factory assembled, wired, internally piped & tested. Outdoor units shall be pre-charged with R 410A refrigerant. Additional charge shall be provided as per refrigerant piping at site. All the units shall be suitable for operation with 415 V + 6%, 50 Hz + 3%, 3 Phase supply for outdoor units and 240 V + 6%, 50 Hz + 3%, 1 Phase supply for indoor units.

   b. VRF/VRV system shall provide stable, trouble free, safe operation, with the flexibility of operating desired indoor units. Outdoor units shall be capable of delivering exact capacity proportional to the number of indoor units switched on and the heat load in the air conditioned area. The proportional operation shall be achieved by varying

Copyright © Buro Happold Limited

speed of the compressor in the outdoor units (variable frequency drives). Electronic expansion valves shall be provided in the system.

c. All compressors of the outdoor units shall be hermetically sealed scroll type. Each module of outdoor unit shall have separate scroll compressor with necessary control, suitable to operate at heat load proportional to indoor requirement
d. Selected outdoor unit condenser fans shall have a 6mm external static pressure to discharge the hot air out and overcome the wind pressure at higher elevations
e. Coils of outdoor unit shall have blygold or equivalent corrosion resistance coating
f. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention
g. Outdoor units shall employ system of equal run time for all the compressors, within each outdoor unit – Single Module or Multi Module.
h. Outdoor units shall be suitable to operate within an ambient temperature range of – 5 Deg C to 50 Deg C in cooling mode
i. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up **to 8mm or above of w. g to overcome the wind pressure.** Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity the system.
j. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.
k. Inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting
l. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
m. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 1.5metre from the unit.
n. Outdoor units shall conform to Technological Guideline for Harmonic Suppression – JAEG 9702 1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%.
o. The system shall be suitable for delivering the design capacity without deration, up to the following distances.

i) Distance between outdoor and furthest indoor unit - 150 mts.
ii) Vertical distance - 50 mts.
iii) Horizontal distance - 130 mts.
iv) Total refrigerant piping in each system - min 500 mts.

p. Operation of the VRV/VRF system shall be through independent wired/ wireless remote controllers.
q. All units shall be supplied with the following from the factory:

v) Connection pipes & accessories.
vi) Clamps
vii) Installation manual
viii) Operation manual
ix) VRV/VRF controller
x) Communication modules for the home automation units.

3. General Features

Following features shall be provided for all VRV/VRF systems.

ON / OFF Control	ON / OFF control for each individual indoor unit.

Copyright © Buro Happold Limited

Central Control	Central or local control shall be individually selected. In built duty cycling shall be provided.
Mode Selection	Simulated COOL/HEAT operation.
Temperature Setting	Temperature selection from `0' Deg.– 30 Deg.C in cooling mode.
Fan Speed Setting	HIGH-MEDIUM-LOW-OFF
Timer	Multiple daily time ON/OFF settings where temperature, fan speeds can be selected.
Remote Controller Group	Indoor units with remote controller.
Group Setting	Multiple indoor units shall be group set with the same settings by inputting the information on one of the units in the group.
Auto Configuration	All indoor units connected to the network shall automatically be identified and registered.
Fault Status	If a fault occurs, the screen shall display the fault details within 3 minutes and a fault log shall be created. Facility to print the log automatically shall be provided.
System Status	Actual operating conditions for each indoor and outdoor unit shall be monitored on the system display graphics.
Password	A password to prevent unauthorized access to the program.
Search	Where many indoor units are controlled by NETWORK, a search function shall be available to find specific unit locations
Languages	ENGLISH
Help Files	Help files shall be provided in the respective languages.
Error Log	All faults reports shall be stored with date and time information providing a historical record.
Unit Registration	Information concerning the unit models, serial numbers shall be entered for each unit making after sales service easier.
Energy Consumption	Shall allow the demand of individual units to be calculated as a percentage of total system energy consumption over selected time periods.
Historical Information	Operation conditions shall be recorded at selected time intervals for help with monitoring and trouble shooting.
Filter Maintenance	An indication shall appear, at selected time intervals, when it is necessary to inspect the filter.

Copyright © Buro Happold Limited

4. Testing:

a. Unit capacity in Tons Refrigeration shall be computed from the temperature readings.

b. All instruments, services needed for the tests required for the computation of capacities and power consumption shall be provided by the Contractor. All instruments shall be calibrated and the Contractor shall produce calibration certificates in support.

5. Painting:

All equipment including mounting frames, etc., shall be painted with two coats of a suitable paint of approved color. All steel members/parts shall be given an undercoat of zinc chromate before the application of 2 coats of paint

B. INDOOR UNITS FOR APARTMENTS

1. Scope :

a. Scope of this section comprises the supply, installation, testing and commissioning of indoor units for VRV A.C. System.

2. General Requirements :

a. All units shall be supplied with the following from the factory:
   i) Drain hose/ clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti-vibration rubber mounts.
   ii) All indoor units coil shall have anti-corrosive coating
   iii) Installation manual.
   iv) Operation manual.
   v) Selected unit shall maintain NC 30-35.
   vi) All Indoor units shall be complete with IR with extended neck sensors and associated control caballing.
   vii) Refrigerant shall be Environment friendly R407C / R410A.

b. All units shall have cordless / corded remote. The remote should have following standard functions including but not limited to the following-
   i) Unit Start / Stop
   ii) Temperature setting.
   iii) Operating mode
   iv) 24 hour on/off timer
   v) Airflow swing activation.
   vi) Fan speed adjustment.
   vii) Memory restart.
   viii) Sleep mode.

3. Wall Mounted Indoor Units

a. Wall mounted indoor units shall be compact and stylish design that does not detract from the décor of the room.

b. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

c. Units shall have provision of adding drain pump kit if required and specified. Drain pumps shall be suitable to lift drain up to 1000 mm from the bottom of the unit.

d. Units shall be insulated with sound absorbing thermal insulation material. Noise level of unit at the highest operating level shall not exceed 35 dB(A), at a vertical distance of 1.5 m from the grille of the unit.

e. Units shall be supplied with maintenance free long life filter, Resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install.

f. Unit grilles shall be washable with soap solution.

g. It shall be possible to set minimum 5 steps of discharge angle by remote controller.

h. It shall be possible to fit drain pipe from either side of the unit (left or right).

Copyright © Buro Happold Limited

i. Units shall be connected in series to a suitable outdoor unit and it shall be possible to operate the unit independently, through cordless remote control specified in the bill of quantities.

4. Ceiling Mounted Indoor Units

a. Ceiling mounted Hide away type indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned directly through duct collar and grille or through duct system specified in these tender documents.

b. Unit casing shall be Galvanized Steel Plate.

c. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

d. Units shall be insulated with sound absorbing thermal insulation material. The noise level of unit at the highest operating level shall not exceed 42 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

e. Unit shall have thermal fuse for fan motor protection, in case of motor heating.

f. Units shall have provision to set external static pressure in three stages as per the system requirements depending on the air supply system.

g. Units shall be supplied with maintenance free long-life filter, Resin Net with Mold Resistance. The filer shall be easy to remove, clean and re-installed.

h. Units shall include a drain pump kit suitable to lift drain water up to 750 mm from the drain pipe opening as an optional equipment.

i. Units shall be connected in series to a suitable out door unit and it shall be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities.

j. Unit shall be able to develop ESP of 15mm-25mm at the specified air quantities.

C. DX OUTDOOR FOR DUCTABLE UNITS (NOT APPLICABLE TO THIS PROJECT)

1. Scope :
Scope of this section comprises the supply, installation, testing and commissioning of outdoor units suitable for Constant Volume Refrigerant System.

2. General Requirements :

a. All outdoor units shall be supplied with the following from the factory:
   i) Clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting.
   ii) Paper pattern for installation.
   iii) Installation manual.
   iv) Operation manual.

3. Materials and Construction :

a. Outdoors units of constant volume refrigerant flow system shall be compact air cooled type.

b. All compressors of the outdoor units shall be hermetically sealed scroll type.

c. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention.

Copyright © Buro Happold Limited

d. Outdoor units shall be suitable for up to 20m (straight length) refrigerant piping between outdoor unit & the farthest indoor units. Allowable level difference between outdoor unit & indoor units shall be 5 meter (minimum).

e. Outdoor units shall employ system of equal run time for all the compressors, inverter or on/ off type, within each out door unit – Single Module or Multi Module.

f. Outdoor units shall be suitable to operate within an ambient temperature range of – 5 Deg C to 50 Deg C in cooling mode .

g. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up to 8 mm of wg. Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity.

h. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.

i. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.

j. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 1.5 metre from the unit.

k. Coils of outdoor unit shall have blygold coating.

l. Outdoor units shall be complete with following safety devices:
   i) High pressure switch
   ii) Fan driver overload protector
   iii) Over current relay
   iv) Inverter overload protector
   v) Fusible plug

D. CEILING MOUNTED DUCTABLE INDOOR UNITS (NOT APPLICABLE TO THIS PROJECT)

a. Ceiling mounted Ductable indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of the operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned, through duct system specified in these tender documents.

b. Unit casing shall be Galvanized Steel Plate.

c. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

d. Units shall be insulated with sound absorbing thermal insulation material. 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.

e. Unit shall have thermal fuse for fan motor protection, in case of motor heating.

f. Unit shall be able to develop external static pressure of 25 mm, at the specified air quantities.

g. Unit shall be connected in series to a suitable out door unit and it shall be possible to operate the unit independently, through corded/ cordless remote control specified in the bill of quantities.

h. Refrigerant shall be Environment friendly R407C / R410A.

i. All units shall have corded remote. The remote should have following standard functions including but not limited to-
   i) Unit Start / Stop
   ii) Temperature setting.
   iii) Operating mode
   iv) 24 hour on/off timer
   v) Airflow swing activation.

Copyright © Buro Happold Limited

vi) Fan speed adjustment.
vii) Memory restart.
viii) Sleep mode

E. SUPPLY/ EXTRACTION /

1. Scope
The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, Tube axial, in-line and propeller type fans and roof mounted units conforming to these Specifications and in accordance with the requirement of Drawings ,Equipment schedule and schedule of Quantities.

Selected fans shall have sufficient static pressure to discharge / intake the air out and overcome the wind pressure at higher elevations

2. Capacity
The air-moving capacity of fans shall be as shown on Drawings, Equipment schedule and in Schedule of Quantities.

3. Type
Centrifugal fans and roof mounted units shall be of the type as indicated on Drawings, Equipment schedule and in Schedule of Quantities.

a. <u>Tube Axial Flow Fan</u>

Fans shall be direct driven **Tube axial** type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement as per approved for construction shop drawings.

Service Lift Lobby pressurization fans.

i) Casing shall be constructed of 14 gauge sheet steel. Fan casing and motor mount shall be of welded steel construction. Motor mounting plate shall be minimum 12 mm thick and machined to receive motor flange. Casing shall be provided with wide hinged doors which should open easily for removal of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be primed and finish coated with enamel paint.
ii) Rotor hub and blades shall be cast aluminum construction. Blades shall be die formed airfoil shaped for maximum efficiency and shall vary in width from hub to top to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5 mm. Rotor blades shall be whirl tested to a speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow values as specified and quoted.
iii) Motor shall be squirrel cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, suitable for 415 ± 6% volts 50 cycles, 3 phase power supply as per latest IS specifications. Motor nameplate horsepower shall exceed brake horsepower by a minimum of **20%.**. Motors shall be quiet operation and motor speed shall not exceed 1500 rpm. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires

Copyright © Buro Happold Limited

from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible conduit.

iv) Motor starters shall be automatic direct on line for rating up to 7.5 H.P. and automatic Star Delta for motors 10 HP & above. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.

v) Drive to fan shall be direct driven.

vi) Vibration Isolation: The assembly of fan and motor shall be suspended from the ceiling or mounted on walls by vibration isolators.

vii) Accessories : The following accessories shall be provided with all fans:
   I. Outlet cone for static pressure regain.
   II. Inlet cone.
   III. Fan silencers, if required.
   IV. Wire guards on fan outlet / inlet not connected to duct work and shall be made freely accessible for maintenance.

viii) Fans shall be factory assembled and shipped with all accessories factory-mounted. For smoke extraction fans, the gaskets shall be suitable for continuous operation in an air stream temperature of 250 °C for two hour or 300^0C for one hour.

b. <u>Centrifugal Fan</u>

Centrifugal fan shall be SWSI or DWDI Class I construction arrangement 3 (i.e. bearings on both the sides), complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

Housing shall be constructed of 14 gage sheet steel welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight.

18 gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

NORMAL VENTILATION

i) Fans shall be non-overloading type. The fan capacity, static pressure, arrangement, width, direction of rotation, mode of discharge, etc. shall be as indicated in the schedule and in the applicable drawings or as required.

ii) Centrifugal fans shall be of the backward curved blade having a fan of total efficiency greater than 70%.

iii) Fan casings shall be constructed from 1.6 mm GSS construction and shall be able to permit withdrawal of impeller after fan installation. Fans shall be provided with flanged outlet connections. Permanent indication shall be provided to show the correct direction of rotation of the fan impeller. Fan casings shall be provided with air tight removable access panels. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller.

iv) Fan shaft shall be of EN - 8 steel constructions.

v) Impellers shall be of 2 mm thick mild steel or aluminum alloy of riveted welded or other approved construction, with spiders or hubs of robust design. Impeller shall be statically and dynamically balanced.

vi) Fans shall also be provided with heavy duty adjustable outlet dampers mounted in a separate frame.

vii) Fans shall be driven by a TEFC Sq. cage motor as per latest IS specifications. Motor ratings are only tentative and where a fan requires a higher capacity motor, the contractor shall clearly point out the requirements and make their offer accordingly. Motor ratings shall be at least 20% over limit load.

Copyright © Buro Happold Limited

viii) Motor starters shall be automatic direct on line for rating as indicated in electrical specification. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.

ix) All class I fans shall be provided with sleeve bearings with generous oil reservoir, drain plug, oil level indicator, etc. Class II and III fans shall be provided with heavy duty ball bearings.

x) Drive to fan shall be through oil resistant type belts with adjustable multi speed pitch motor pulley and approved belt guard. Pulleys shall be well balanced and properly aligned.

xi) Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through Resistoflex or approved equal vibration isolators. The concrete foundation shall be at least 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings

2.2 PRODUCT SPECIFICATION

A. Piping

The scope of this section comprises the supply and lying of pipes, pipe fittings and support, testing and balancing of and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards. 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 smooth noiseless balanced circulation of fluids.

References:

- ASTM B68/1995 and ASTM-B75/1983- copper tubes used for Refrigerant purpose
- ASTM-E243 - Standard Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
- BS 864-Part II - Specification for Capillary and Compression Fittings for Copper Tubes
- BS EN 29453 - Soft solder alloys. Chemical compositions and forms
- BS 1723 - Brazing. Methods for non-destructive and destructive testing

1. **Refrigerant Piping – Materials and Construction:**

a. All refrigerant piping shall be of copper tubes conforming to ASTM B68 / 1995 and ASTM – B75/1983
b. Copper tubes shall be seamless, bright annealed with clean inside surface, free from all impurities.
c. Material of the tube shall be Phosphorous Deoxidized High Residual Copper with minimum 99.9% copper and 0.015% to 0.040% phosphorous.
d. Copper tubes shall have the following properties:

Sr. No.	Properties	Soft Annealed (ASTM-B68)	Hard Drawn (ASTM-B75)
a)	Tensile strength	30 ksi (min)	45 ksi (min)
b)	Elongation	40% (min)	Not required
c)	Hardness	60 HV5 (max.)	55 HV5 (min)
d)	Grain size	0.040 (min.)	Not required
e)	Expansion	40% (min)	Not required

Copyright © Buro Happold Limited

e. All tubes shall be 100% eddy current tested as per ASTM – E243 and test certificate submitted.
f. All tubes shall be carbon film tested and test certificate submitted. Maximum residual carbon shall be 0.1 mg/dm_2.
g. All tubes shall be deburred at both ends.
h. All tubes shall be free from carbon oxide or any other contaminant. Tubes for Non-CFC gas such as R134a, R410a, R600 etc. shall not be subjected to paraffin, wax, acids, chromium etc. in the factory and shall be cleaned & supplied without residues / oxides or carbon in the ID.
i. All tubes shall be pre-filled with nitrogen and capped on both sides before supply.
j. Tubes shall be ROHS (Restriction of hazardous substances) complied as per EC directives for hazardous substances including mercury, lead, cadmium & hexavelent chromium.
k. Contractor shall submit all test certificates including Hazardous Substance Compliance Certificate.
l. All hard tubes shall be printed with manufacturer's name, specifications, size, hardness at regular intervals.
m. Tubes shall be duly capped and packed in polythene bags. Capillary and compression fittings of copper and copper alloys shall conform to BS 864-Part II. Solder wire and brazing alloys shall conform to BS EN 29453 and BS 1723 respectively.
n. Selected piping material shall have sufficient corrosion resistance and shall work for at least 15 years without any change in property for sea climate.
o. Line velocities for pipe sizing shall be as follows:

a) Suction - 6 to 20 MPS
b) Discharge - 10 to 17.5 MPS
c) Liquid - 0.5 to 1.25 MPS

Contractor shall submit a schematic piping diagram for each type of refrigeration machine.

2. Condensate Drain Piping

All pipes to be used for condensate drain and fittings in apartments shall be high pressure UPVC conforming to relevant IS : 4985:2000 and pressure rating of 2.5 bar & Pressure Class-1. Pipes shall be joined using UPVC solvent cement confirming to IS: 4985. UCPVC fittings i.e. Tees, Elbows, Couplers, Unions, Reducers shall be conforming to IS: 7834 Part 1 to 8. AC condensate drain piping shall be indicated in Plumbing drawing. Corresponding drawing reference number shall be indicated on HVAC drawing. Drain piping as shown in the HVAC drawings or up to 10 meters from Indoor unit is in HVAC Contractors scope.

a. Proper slope (Minimum 1:100) shall be provided for better drainage. U trap shall be provided at outlet of the unit.
b. All condensate drain pipe sizes shall be as per BOQ & drawings.
c. All condensate drain piping shall be insulated as per the section "Insulation" as indicated in Schedule of Quantities.

B. Air Distribution

1. Scope

The scope of this section comprises supply fabrication, installation and testing of all sheet metal / Pre insulated , supply, installation, testing and balancing of all grilles, registers and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings.

2. Duct Materials

Galvanizing shall be Class VIII – light coating of zinc, confirming to IS-655-1963, nominal 120gm/Sq.M surface area and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at ran-

Copyright © Buro Happold Limited

dom by Employer's Representative/consultant shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

Fabrication of ducts shall be through well-conditioned Triplex lock former or multiple lock formers, conforming to relevant SMACNA Codes.

Rectangular Ducts G.S.	**External Pressure 250 Pa**		
	Duct Selection Length 1.2 Meters (4 feet)		
Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1-750 mm	26	C & SS	Nil
750 - 1000mm	26	4 Bolt Transverse Duct Connector - E (TDC) with built in sealant	Nil
1001-1200mm	24	4 bolt TDC - E	Nil
1201 - 1500 mm	24	4 bolt TDC - H	Nil
1501 - 1800 mm	22	4 bolt TDC - H	600mm from joint
1801 - 2100 mm	20	4 bolt TDC - J	600mm from joint
2101 - 2700 mm	18	4 bolt TDC - J	600mm from joint

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm

*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

3. Fabrication Standards & Equipment

c. All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.

d. Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.

e. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.

f. All edges to be machine treated using lock formers, flanges and rollers for turning up edges.

g. All ducts shall be fabricated and installed in workmanlike manner, generally conforming to relevant SMACNA Codes. Round exposed ducts shall be die-formed for achieving perfect circle configuration.

h. Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section "Insulation" and as indicated in Schedule of Quantities. Duct dimensions shown on Drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of Quantities.

i. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.

j. All exposed ducts up to 60 cm width within conditioned spaces shall have slip joints - or flanged joints. The internal ends of slip joints shall be in the direction of air flow. Ducts and accessories within ceiling spaces, visible from air conditioned areas shall be provided with two coats of mat black finish paint.

k. Changes in dimensions and shape of ducts shall be gradual. Air-turns (Vanes) shall be installed in all bends and duct collars designed to permit the air to

Copyright © Buro Happold Limited

make the turn without appreciable turbulence's. Ducts shall be fabricated as per details shown on 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.

l. 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 gage GSS / 16 gauge aluminum, thoroughly stiffened with 25 mm x 25 mm x 3 mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to
give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.

m. Plenums shall be panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards G S sheet and riveting shall be done from outside.

n. Self-adhesive rubber lining minimum 5 mm thick instead of felt shall be used between duct flanges and between duct and duct supports in all ducting installation.

o. All ducts shall be installed generally as per tender Drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor.

p. 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 Owner's site representative in all its parts and details.

q. 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 on 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.

r. 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 approval of Owner's site representative.

s. 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 centre. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. 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. Wherever use of metal insert plates is not feasible, 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.

t. Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building.

u. 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 fire sealant such as fire barrier mortar for complete sealing.

v. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by

Copyright © Buro Happold Limited

independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

w. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

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

y. Toilet exhaust duct shall be provided with goose necking as shown in design drawings.(if applicable)

4. Volume Control Dampers

a. All duct dampers shall be opposed blade louver dampers of robust 16 G GI construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.

b. The blades shall be coupled with the frame by external cross linkage. Linkage rods shall be coupled with hand locking quadrant with open & close marking. Bushings used are made of self-oiling nylon type.

c. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and easily accessible. Every damper shall have an indicating device clearly showing the damper position at all times.

d. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

e. The VCD shall be located in such a way handle operating mechanism shall be clearly visible though the trap door in the false ceiling. Damper position (open, ½, close) shall be marked on body & clearly visible through Access door in the false ceiling.

f. All linear bar grilles shall have collar damper for control purpose.

F. Pressure Relief / Gravity Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. Extruded aluminum Pressure relief / Gravity adjustable counterbalance horizontally mounted damper. This damper open by air pressure differential & close by gravity.

b. These dampers shall be rated for the velocities up to 2000 fpm & pressure up to 65mm of water gauge. They shall be rated for temperature 82 Deg C.

c. Damper shall consist of heavy gauge extruded aluminum channel frame 3.2mm thick, 79mm depth, blades from 1.8mm extruded aluminum, 19mm dia metallic axles turning in acetal bearings. Damper shall be equipped with extruded vinyl blade seal & internal U 3mm plated steel blade to blade linkage with counterbalance weights.

G. Motorized Fire & Smoke Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. All supply and return air ducts at fire wall crossings and at all floor crossings shall be provided with Motorized Fire & smoke damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555/UL555S 1995 tested by CBRI. 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. Control Panel shall have Form fit type of mounting, metal enclosure and guaranteed long life span.

b. Fire damper blades and outer frames shall be of 16G galvanized steel construction 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.

c. Fire resistance rating shall be on the either side of the Fire damper.

d. The electric actuator shall be energized upon receiving a signal from the Fire Alarm panel. The fire damper shall also close upon sensing temperature rise in supply air ducts through the electronic temperature sensor.

Copyright © Buro Happold Limited

e. Each damper shall be provided with its own control panel with actuator, mounted on the wall and suitable for 240 VAC supply. IP rating of the control panel shall be IP-56 for outdoor applications. This control panel shall be suitable for spring return actuator and shall have at least the following features:
   - Potential free contacts and remote alarm indication.
   - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
   - Fail safe position
   - Test and reset facility.
   - Indicating lights / contacts to indicate the following status:
   - Power Supply On
   - Alarm
   - Damper open and close position.

f. Control Panel shall be mounted on the external part of 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 its control panel. Control panel shall be wall mounted type.

g. MSFD shall be of low leakage design qualified to UL555S leakage class I. The combination of Fire & smoke dampers shall not exceed maximum temperature rating of 177 Deg C as per NFPA 90A.

h. As per NFPA-92A-6.4.3.6, the smoke-control mode shall be initiated within 10 seconds after an automatic or manual activation command is received at the smoke-control system.

i. The time necessary for individual components to achieve their desired state or operational mode once the component receives the signal shall not exceed the following time periods: Fan operation at the desired state: 60 seconds & Completion of damper travel: 75 seconds

j. 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 alarm / Building Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire alarm system contractor.

k. 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 energizing all the smoke detectors with the help of smoke.

l. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.

m. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site.

n. 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.

o. The Contractor shall also furnish to the Owner, the necessary additional spare control panels and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

H. Fire Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. Whenever a supply/return duct crosses from one fire zone to another, floor crossings it shall be provided with approved fire damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555 1995 tested by CBRI.

This shall be curtain type fire damper. For fire zoning kindly refer to the drawings issued by architect.

b. Fire damper blades shall be one piece folded high strength 21 gauge galvanised steel construction Body shall be in 20 G and sleeve in 16 G. In normal position, these blades shall be gathered and stacked at the frame head providing 100% air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 71 Deg C as specified in NFPA 90A.

c. Fire resistance rating shall be on the either side of the Fire damper.

Copyright © Buro Happold Limited

d. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.
   - Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
   - The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

I. Supply and Return Air Registers **(NOT APPLICABLE TO THIS PROJECT)**

a. Supply & return air registers shall be of either steel or aluminum sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminum registers shall be either Anodized or Powder Coated as specified in Schedule of Quantities. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminum volume control damper anodized in matt black shade.

b. The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminum construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (none on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminum anodized in black colour shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.
   - All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.
   - All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.
   - Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45 degree horizontal arc and up to 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
   - Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

5. Linear Bar Grilles

Linear bar grilles shall be fabricated from aluminum, with 6.4mm wide bars on 12.5mm centers pressed into a notched steel retaining bar. The core can be either welded into the cuter frame, or, where the grille is used in a sill application, held in the outer frame by spring clips fixed to the core retaining bar.

The outer frame shall be 35mm deep and shall have a visible flange 25.4 mm wide. Mi-tred end caps shall be welded to give a near invisible joint.

The grill shall be complete with an opposed blade damper painted matt black, and shall be fixed with universal mounting brackets. Both the damper and the fixing brackets shall be accessible through the face of the grille.

Continuous grilles shall be provided with positive alignment strips, which fit into special

Copyright © Buro Happold Limited

keyways extruded into the frame of the grille to ensure clean unbroken lines.

All pressurization grilles shall be with Volume control dampers.

J. Linear Slot Diffusers **(NOT APPLICABLE TO THIS PROJECT)**

Linear Slot diffusers shall provide an unobtrusive continuous air diffusion with a pleasing aesthetic appearance. Hairline butt joints shall ensure clean unbroken linear runs for active and dummy sections. Slot width shall be 20 mm, unless otherwise indicated.

The diffusers shall be complete with pattern control blades, fully adjustable from face of diffuser through 180 degrees and shall be fitted with end caps at each end.

The diffuser members shall be constructed from high quality aluminum extrusions to BS 1474 while the pattern control blades shall be of black rigid PVC.

6. Louvers

a. Materials of Construction / Fabrication: Louvers shall generally be fabricated from extruded aluminum sections with mitered joints; unless otherwise stated or dictated by selection with minimum free area of 60%.

b. Finishing:

Louvers shall have anodized / polyester powder coated colored finish, selected to match with the surrounding architectural finishes.

c. Manufactures to submit performance data based on AMCA 500 - Test Method for Louvers, Dampers and Shutters

d. Construction :

Single angled louvers of 2.5 mm (12 gauge) thick, 100 mm (4 inch) deep blades set at 45° slope with centre baffle and return bend; set in heavy channel frame.

e. Accessories (for air intake):

i) Exterior flat flange for installation on walls

ii) 19 mm (3/4 inch) square mesh, bird screen; opposed blade, gang operated, volume control damper with removable key operator, adjustable from the grill face

iii) 100 mm (4 inch) panel type washable air filter

f. Accessories (for exhaust):

i) 13 mm (½ inch) square mesh, bird screen

Note- Grille, Diffuser, Register & Louver color code shall be as per the Architect approval. Sample is required for approval prior to ordering air side equipments.

C. INSULATION

1. Scope of this section comprises the supply, installation and testing of insulation as herein Specified and as per the requirements of Indian Standards.

2. General:

a. All tests like pressure testing should be completed and recorded and all systems approved by the Owner/ Consultants before insulation is applied to the equipment, piping and ducting. Insulation material shall be manufactured by approved manufacturers and shall be of the type intended for the services specified.

b. Insulation materials and finishes shall be inherently proof against rotting, mould, fungal growth and attack by vermin, be non-hygroscopic and in all respects be

Copyright © Buro Happold Limited

suitable for continuous use throughout the range of operating temperatures and within the environment indicated.

c. Unless otherwise indicated, all thermal insulating materials used within the building shall, tested in accordance with ISHRAE. Alternatively, all thermal insulating materials used within the building shall be noncombustible with a facing of combustible material provided the facing is not more than 0.8 mm thick. Thermal insulating materials used within the building shall be free from substances which in the event of a fire would generate appreciable quantities of smoke, noxious or toxic fumes. When instructed by the Owner/ Consultants, evidence of fire classification, obtained from an approved testing laboratory, shall be provided by the Contractor in order to certify that materials comply with this clause.

d. Thermal insulation shall be applied to air distribution ductwork and to components within distribution systems such as fans and cooler casings which convey conditioned air within plant rooms and to ductwork (including recirculation air ductwork) conveying warmed or chilled air through unconditioned spaces or the open air. Distribution system conveying treated fresh air and apartment toilet exhaust air shall be insulated.

e. Thermal insulation shall be applied to refrigeration pipe distribution system and to Components within distribution system.

f. Where thermal insulation is applied to the outside of pipes, ducts, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated in the documents, a water vapour barrier shall be provided. The vapour barrier shall be applied such that it will be continuous and will give protection to the whole surface of the insulation, which it will be protecting. The vapour barrier shall not be pierced or otherwise damaged by supports or by the application of external cladding. At points of support, means of load distribution shall be provided as necessary.

g. Adhesive Coating provides a protective finish for insulation refrigerant piping when applied in 2 coats with reinforcing fabric embedded between coats. When relative humidity exceeds 75% for continuous periods, additional vapor barrier protection is suggested. Adhesive Coating shall be produced under the classification and follow-up service of Underwriter's Laboratories, Inc. and meets NFPA 90A and 90B 25/50 requirements. Adhesive Coating shall not contain asbestos, lead, mercury, or mercury compounds. Coating shall be applied strictly as per the manufacturer's specifications.

h. At all points of support, both insulation and out covering shall be continuous and shall not be punctured or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to take the loads transmitted to the supports. The load- bearing insulation shall be extended on each side of the supports.

i. Only Aluminum tapes shall be allowed for the insulation joints and at the insulation Termination point.

j. At entries into buildings the weather-proofed insulation shall extend not less than 100 MM (4") beyond the inner face of the wall and be sealed to the satisfaction of the Architects/ Consultants.

3. Insulation material**:**

SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of the thermal and acoustic insulation for ducts and pipes.

Copyright © Buro Happold Limited

a. Material shall be insulated with flexible, closed cell, elastomeric, class 'O' nitrile rubber tubing or equivalent, of uniform density 60 t0 70 kg/cu.mt with the following properties:

   i. Thermal Conductivity:
      Less than 0.037 w/m.K at 0°C (as per BS 874 Part 2 1986 or DIN 52613).

   ii. Water vapour permeability:
      As per Din 52615, shall not exceed **0.15ng/m.sec.pa**.

   iii. Water absorption:
      Less than 1% by volume.

   iv. Fire performance:
      i) Surface spread of flame: Class 1 (BS476 Part 7, 1987)
      ii) Fire propagation (Total index) : Less than 12 (BS476 Part 6, 1989)

   v. The material shall be rated as **class 1**, as per **bs 476 part 7**. the rating as per **din 4102** shall be **b1**.

   vi. The **smoke density** of the material as per **AS-1530.3** shall not exceed **1.**

   vii. The material shall have a fire approval from CBRI/fire advisor (govt of india)/chief fire officer.

   viii. For providing uv protection the insulation shall be cladded with minimum 30 micron aluminum p e foil. The cladding shall be factory finished to avoid site work. The insulation material will be provided with self-adhesive covered peel off paper, (as an alternative).

   ix. Temperature Range:

      0°C to 50°C

   x. Performance:
      Guaranteed absence of condensation for all fluids at 5^0C in Mumbai ambient air conditions.

b. Pipes and ducts running at mechanical floors , outdoor or exposed on roof shall be, covered with 0.6mm (26 g) aluminum jacket on top of insulation.

c. Vapour barrier coating shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e outside the air conditioned area).

d. Drain piping shall be insulated with 9mm thick insulation applied in the same manner as specified for refrigerant piping.

e. All valves, fittings, strainers, etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

Copyright © Buro Happold Limited

Following thickness shall be followed while selecting material for different applications

Sr. No	Type Of Duct / Pipe	Area served	Insulation Material Properties		Protective Jacket
			Thick-ness In (mm)	Density (Kg / m^3)	
1	Supply and return Air AC Duct	Running In AC Area	19	60	Not Required
2	Supply and return Air AC Duct	Running In Non AC Areas such as enclosed in risers / shafts	25	60	Not required
3	Supply and return Air AC Duct	Running In Plant room / po-dium (Exposed Ducting) Ar-eas	25	60	Required, 26 G aluminium Clad-ding
4	Refrigerant pipes	Running In AC or Non AC Areas	19	60	
5	Refrigerant pipes	Running In Plant room / po-dium service balcony Areas	19	60	Required, 26 G aluminium Clad-ding

Copyright © Buro Happold Limited

4. Acoustic Insulation material:

   a. Connecting duct of Indoor unit shall be provided with internal acoustic lining for a distance of 3.0 meters (10'0") from the outlet with elastomeric nitrile rubber conforming to the following standards and specifications:

a) Thickness	: 19 mm for 3Mtrs. length of indoor unit outlets.
b) Density	: 60-80 kg/cum
c) Acoustic Values	: Greater than 1dB/m in the frequencies below 250Hz and greater than 5dB/m for frequencies 500 Hz and above in ducts of 600x500mm size
d) Temperature Range	: 5^0C to 50^0C
e) Fire Safety	: Non combustible in accordance with BS476 (1970) Class 'O' fire rating
f) General	: Should be chemically inert odorless, rot/ fungi/ vermin proof, should be dimensionally stable and should not be prone to sagging.

K. FIRESTOPPING AND SMOKE SEALS (NOT APPLICABLE TO THIS PROJECT)

1. For penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating services, provide through-penetration fire stop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

   a. Rated Systems: Provide through-penetration fire stop systems with the following ratings determined per ASTM E 814 or UL 1479 or NEC 300-21

   b. For through-penetration fire stop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

      - For exact details of fire sealing arrangement for fire dampers, kindly refer the drawings.
      - For floor penetrations with annular spaces exceeding 100 mm in width and exposed to possible loading and traffic, provide fire stop systems capable of supporting floor loads involved, either by installing floor plates or by other means.
      - For penetrations involving insulated piping, provide through-penetration fire stop systems not requiring removal of insulation.
      - Provide fire stop compounds for caulk, pour, trowel or pump application. Material must be capable of sealing openings around single or multiple pipes, cables against fire, smoke and toxic gases, and maintaining rating with a thickness no greater than the structure. Material shall be approved by Client's Representative and Local authorities.
      - For cable penetrations cementatious material and paint for cables up to 1 meter approx. can be used

2. Provide fire-resistive joint systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly in which fire-resistive joint systems are installed.

Copyright © Buro Happold Limited

a. Joint Systems in and between Fire-Resistance-Rated Constructions: Provide systems with assembly ratings equaling or exceeding the fire-resistance ratings of construction that they join, and with movement capabilities and L-ratings indicated as determined by UL 2079.

b. For fire-resistive systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84

END OF PART 2

Copyright © Buro Happold Limited

PART 3 EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare all the materials / Equipment, are according to the following:

1. Ensure that material / Equipment are dry and internally protected against rust and corrosion.

B. During Storage: Use precautions for material / equipment, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle equipment if size requires handling by crane or lift. Rig equipment to avoid damage to exposed parts

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored material from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect the material and equipment from moisture and dirt.

G. Store the material & equipment protected from direct sunlight. Support to prevent sagging and bending.

H. Delivery, Storage & Handling of material & equipment shall be strictly as per OEM / Manufacturer recommendation & guidelines.

I. Delivery, storage, Handling & Safe keeping shall be contractor scope of woks. Storage space shall be provided by the Client.

3.2 REFRIGERANT PIPE INSTALLATION

a. 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.

b. 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, clamps and hangers and be responsible for their structural sufficiency.

c. Wherever pipes pass through a fire rated wall / slab openings, the gaps shall be sealed with fire sealant of approved make.

d. All refrigerant piping shall be laid in cable trays. Direct clipping of pipes on ceiling or wall shall not be acceptable.

e. Refrigerant piping will be installed in following manner

- Cut the correct length of pipe with a tube cutter. End of the tube shall be cut at right angle to the axis. All burrs shall be removed with a file.
- Clean the outside and inside surface using cleaning pads or fine sand paper.

Copyright © Buro Happold Limited

- Apply water soluble thin film of flux to the tube and fittings, to prevent copper from oxidizing and to ensure that the molten solder bonds the tubes and fittings.

.

- Insert the tube into the fitting and push until the stop is reached. Wipe off excess flux with clean cloth.

- Apply heat on the assembled joints using lamps emitting clean, blue and soot free flame, till complete ring of the solder appears around the mouth of the fitting.

- Allow the joint to cool without disturbing the joint.

- Wipe off excess flux and other foreign matter.

3.3 CODENSATE DRAIN PIPE INSTALLATION

a. Design Drawings indicate schematically the size and location of drain 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.

b. Suitable U Trap shall be provided to condensate drain piping

c. Condensate drain should be shall be connected to nearest drain point as indicated in drawing.

d. The joints shall be properly sealed so that there is no leakage.

3.4 DUCT WORK INSTALLATION

a. All ductwork shall be constructed, reinforced, supported and installed in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible'.

b. All supply and return ductwork within 4.5 m of the air conditioning unit, measured from the unit along the duct, shall be 24 gauge sheet metal or heavier, but shall otherwise meet the aforementioned pressure and seal classes.

c. Ducts with a side dimension greater than 900 mm passing above acoustically rated areas (other than corridors) shall be fabricated from 18-gauge or thicker sheet metal. Ducts thinner than 22-gauge and pre-insulated ducts are unacceptable on this project.

d. Fire retardant canvass & rubber duct connectors with a minimum face length of 100 mm shall be Used between the ducts and fans or Ductable units.

e. Make all laps in the direction of air flow. Hammer down all edges and slips so as to leave smooth finished surface inside the ducts.

f. All ducts shall be braced and stiffened and shall be tight so that they will not breathe, rattle, vibrate or sag. Cross-break or transverse bead all rectangular ducts with heights or widths of 300 mm or larger.

g. Duct sealant shall be manufactured by tender specified approved manufacturer and of food grade quality. Brush joints with the compound before and again after assembly. Exposed ducts shall be sealed on the inner surfaces only.

Copyright © Buro Happold Limited

h. The Nexus or Ductmate 4-bolt duct connection maybe used to connect lengths of square or rectangular Duct. Intermediate reinforcing and longitudinal joints shall be as specified above. These proprietary connections shall be installed as shown in the Manufacturer's literature.

i. Seal the bottom and side joints of fresh air ducts or plenums to be watertight.

j. Flexible duct connections shall be of Class 1, corrugated aluminum flexible duct suitable for 1200C and 1.5 kPa and shall bear the 'building unit' label of Underwriters' Laboratories. Flexible duct connections shall be insulated with 25 mm fibre glass insulation with density of 24 kg/m3 complete with vapour barrier.

k. Bends in flexible ducts shall have centerline radius of not less than 1 1/2 x diameter. Collars to which flexible ducts are attached shall be a minimum of 50 mm in depth. Metal flexible ducts shall be attached using a minimum of three #8 sheet screws equally spaced around duct. Ducts larger than 300 mm diameter shall have a minimum of five #8 screws. Screws shall be located at least 12 mm from duct end. Insulation and vapour barriers on factory-fabricated ducts shall be fitted over cone connection and supplementally secured with a draw band.

l. Generally more durable and noise-resistant sheet metal ducts are preferable to flexible ducts in connecting ducts to diffusers or boxes. However, flexible ducts may be used under the following conditions:

    - Shown on drawings to allow easy location of diffusers does not pass through floors or fire walls and does not exceed 2.4 m in length. Flexible ducts shall not be installed in inaccessible locations, such as above gypsum board ceilings unless specific approval from the Consultant is obtained.

m. Where ductwork passes through a wall or floor, other than when a fire damper is required, pack around the duct using a fire resistant material to ensure a sound and air-tight joint. Cover the opening with sheet metal flange of the same metal thickness of duct, overlap opening on four sides by at least 38mm.

n. All supply linear bar grilles shall have string dampers for control purpose

o. Install ducts with fewest possible joints.

p. Install ducts with a clearance of 1 inch (25mm), plus allowance for insulation thickness.

q. Locate all sheet metal ducts where shown and size as shown. If changes of size or location of ducts are found necessary because of building construction, make a specific proposal for review by the Consultant prior to proceeding with the change.

r. Make changes of direction of horizontal ducts with elbows having an inside radius not less than the width of the duct. Make change of direction from horizontal to vertical duct with elbows having an inside radius equal to the depth of the duct. Where this is not possible due to the building construction, use turning vanes.

s. Provide access ports at convenient locations in all main ducts and main branch takeoffs with airtight covers and extension sleeves through insulation to allow air meter readings. Access ports shall be similar to 32 mm round openings as manufactured by E.H. Price or approved equal.

t. Provide flexible connections as specified at each building expansion joint, air handling unit and fan duct connection.

u. Paint visible internal surface behind each grille or register flat black.

Copyright © Buro Happold Limited

v. Where duct is acoustically lined, duct dimensions shown are net, inside of lining.

w. For duct construction refer to the chart given in section B.

x. Sheet thickness shall be in accordance with SMACNA standard.

y. All duct works support used for the project shall be factory galvanized.

z. Volume control damper joints with ductwork shall be flanged joint.

3.5 INSTALLATION OF DUCT THERMAL INSULATION

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.

2. The duct should be inspected and all joints should be sealed against leakages.

3. For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturer‘s Installation Manual.

4. The duct should be covered with two coats of cold applied bitumen/CPRX or any other equivalent approved product.

5. The insulation of specific R-value and thickness should then be cut to appropriate length and stuck to the duct while the adhesive is still wet. For proper laying technique, refer to manufacturer’s Installation Manual.

6. All longitudinal joints and circular overlaps should be sealed with reinforced aluminum foil tape (50mm width) to make the installation leak proof. For large ducts, where adhesive pins have been used, speed washers/clips should be covered completely with Aluminum foil-tape to have an air-tight finish.

7. The insulation should then be secured over the duct using mechanically fastened nylon/steel straps (12mm/50mm) at appropriate intervals (max 1.2m).

8. After the installation the vapour retarding foil should be inspected and all tears should be sealed with Aluminum foil-tape to prevent air leakage.

3.6 INSTALLATION OF DUCT ACOUSTIC INSULATION

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.

2. The duct should be inspected and all joints should be sealed against leakages.

3. Duct acoustic lining shall be provided for a distance of minimum 3 meters.

4. The inside surface for the ducts shall be covered with adhesive, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square.

5. Cut panels 60 x 60 cms of resin bonded fiber glass 25 mm thick shall be fitted in the squares.

6. These insulation panels shall be fixed to the sheet metal with cold setting adhesive compound. The inner most surface shall be covered with fiberglass tissue and 28 gage perforated aluminum sheet having at least 15 percent perforations.

7. The aluminum sheet shall be screwed to GI channels using cup washer and neatly finished to give true inside surface.

Copyright © Buro Happold Limited

3.7 INSTALLATION OF REFRIGERANT & CONDENSATE DRAIN PIPING INSULATION

Application of Refrigerant pipe insulation shall be as follows:

a. No insulation shall be applied until the pipe is satisfactorily pressure tested.

b. Pipe shall be thoroughly cleaned with wire brush and rendered free from all rust and grease.

c. Sleeve the insulation tube onto the pipes.

d. Seal all joints by proper adhesive.

e. For pipe insulation the material should be cut using a die /template to be provided by the manufacturer to ensure proper 45^0 angle is cut and the joining/overlapping of the insulation does not cause any buldging, or stretching

f. All valves, fittings, etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

g. Vapour barrier coating shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e. outside the air conditioned area).

3.8 QUALITY ASSURANCE,INSPECTION, TESTING AND COMMISSIONING

A. Scope

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

i. Provide quality assurance program (QAP), works quality assurance program (WQAP), field quality assurance program (FQAP) and quality plan.
ii. Tests at manufacturer's works.
iii. Perform site tests and commissioning.

B. Submittals

i. After award of work following information shall be submitted.
   a. Quality Assurance Program (QAP)
   b. Works Quality Assurance programme (WQAP)
   c. Field Quality Assurance Programme (FQAP)
ii. For inspection and testing, submit inspection and testing procedures, programme, record sheets applicable at each hold point.
iii. After completion of testing, submit test records, packaging, transportation and storage instructions and methods.
iv. For site installation and commissioning, submit installation methods or procedures, notification and procedures for pre commission and commissioning.
v. After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

C. Quality Assurance Concept And Control

i. Minimum requirements for establishing and implementing a quality assurance programme shall be applied to all aspects of the work necessary for carrying out the contract. Quality assurance shall extend to material parts, components, systems and services as a means of obtaining and sustaining the reliability of critical items, operating performance, maintenance and safety.
ii. Acceptance of the Contractor's quality assurance programme does not relieve the Contractor's obligation to comply with the requirement of the contract document. If the pro-

Copyright © Buro Happold Limited

gramme is found to be ineffective, then the Owner's site representative reserves the right to request for necessary revisions of the programme.

iii. The Contractor is required to produce readily identifiable documentary evidence covering the extent and details of both his own and his sub contractor's quality assurances system as follows :
   a. Quality Assurance Program (QAP)
   b. Works Quality Assurance programme (WQAP)
   c. Field Quality Assurance Programme (FQAP)
   d. Quality Plan.

iv. These documents shall be prepared separately and submitted to the Owner's site representative at the time of starting the work.

v. Quality Plan and Manual shall be prepared by the Contractor for all items and services to be supplied, after the contract has been placed, but before commencement of fabrication, and shall be subject to evaluation and acceptance by the Owner's site representative before start of work.

D. Quality Assurance Manual (QAM)

i. The QAM shall be a general comprehensive document outlining the Contractor's basic organization, policies and procedures. The information to be given in the QAM shall include but not limited to :
   a. Quality Policy.
   b. Quality Assurance Programme
   c. Organization Structure showing inter relationships.
   d. Functional responsibilities and levels of authority.
   e. Lines of communication.
   f. Customer relations.
   g. Laboratory Facilities.

E. Works Quality Assurance Programme (Wqap)

i. The WQAP shall identify the Contractor's Quality Assurance Programme at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the programme elements to be designed, developed, executed and maintained by the Contractor for the purpose of ensuring that all supplies and services comply with this specifications.

ii. The information to be given under this programme shall include but not limited to : Organization and Responsibility.
   b. Contract Review.
   c. Design and Document Control.
   d. Procurement Control.
   e. Production Control.
   f. Control on Sub-contractors.
   g. In-process Quality Control and Traceability.
   h. Inspection and Testing.
   i. Control of Non-conformances.
   j. Corrective Action.
   k. Control of Inspection, Measuring and Test Equipment.
   l. Handling, Storage, Packaging and Delivery.
   m. Records.
   n. Quality Audits.
   o. After - Sales Servicing.

F. Field Quality Assurance Programme (Fqap)

i. This programme shall identify the Contractor's Quality Assurance Programme at site applicable throughout site construction, erection and commissioning. It is the underlying philosophy that the quality built into the product at works shall be maintained throughout the construction and commissioning stages.

II. While, in principle, the FQAP shall include the items discussed in WQAP, it shall, however, be approached differently to take into account site conditions.

III. The FQAP shall include, but not limited to the following information :
   a. Organization and responsibility.
   b. Control of Drawings and Documentation.

Copyright © Buro Happold Limited

c. Product Checklist.
d. Control and Traceability of Purchased materials and services.
e. Receipt Inspection of materials at site.
f. Material Storage Control.
g. Inspection and Examination Procedures.
h. Control of Painting and Insulation Works.
i. Pre-commissioning.
j. Commissioning.
k. Control of Non-conformances.
l. Corrective Action.
m. Control of Inspection, Measuring and Test Equipment.
n. Records.
o. Complétion Documents.
p. List of recommended spares and tools.
q. Personal Training.
r. Servicing during Defects Liability Period.

G. Quality Plan

I. The contractor shall be required to prepare manufacturing and construction/erection quality plans for all equipment items and services. The quality plan shall also define the involvement of Owner's site representative in the inspection and test programme.

II. The Quality Plan shall incorporate as appropriate :

a. Charts indicating flow of materials, parts and components through manufacturing quality control inspection and test to delivery and erection.

b. The charts shall indicate the location of hold points for quality control, inspection and test beyond which manufacture shall not continue until the action required by the hold point is met, and the documentation required is generated.

c. The control documents associated with each hold point, i.e. drawings, material, specification, Works Process Schedule (WPS), Process Quality Records (PQR), quality control methods and procedures and acceptance standards.

H. Site Quality Control Section

I. The Contractor's Quality Control (Q.C.) section shall be headed by an experienced Quality Control Engineer. He shall be assisted by other supervisors. The section shall be an independent one, reporting to the contractor's Site Manager only on administrative matters, but otherwise under full control by the Contractor's Corporate Quality System Management.

II. The Contractor's Q.C. Section shall liaise closely with the Owner's site representative in charge of Quality Assurance/Quality Control, and to whom it shall give fullest cooperation. It is the underlying principle of this contract document that while the Contractor's Q.C. Engineer implements the Contractor's Quality Programme, the adequacy and effectiveness of that implementation shall be audited by the Owner's site representative whose recommendations on improving or maintaining quality shall be acted upon promptly by the Contractor's Q.C. Section.

I. Inspection And Testing

I. All equipment and components supplied may be subjected to inspection and tests by the Consultant/ Owner's site representative during manufacture, erection/installation and after completion. The inspection and tests shall include but not be limited by the requirements of this contract document. Prior to inspection and testing, the equipment shall undergo pre-service cleaning and protection.

II. Tenderers shall state and guarantee the technical particulars listed in the Schedule of Technical Data. These guarantees and particulars shall be binding and shall not be varied without the written permission of the Owner's site representative.

III. No tolerances shall be allowed other than the tolerances specified or permitted in the relevant approved Standards, unless otherwise stated.

IV. If the guaranteed performance of any item of equipment is not met and / or if any item fails to comply with the specification requirement in any respect whatsoever at any stage of manufacture, test or erection, the Owner's site representative may reject the item, or defective component thereof, whichever he considers necessary; and after adjustment or modification as directed by the Owner's site representative, the contractor shall submit the item for further inspection and /or test.

Copyright © Buro Happold Limited

V. The approval of the Owner's site representative of inspection and/or test results shall not prejudice the right of the Owner's site representative to reject an item of equipment if it does not comply with the contract document when erected, does not or prove completely satisfactory in service.

VI. The Contractor shall be responsible for the timely transmission of the relevant and appropriate sections of the contract document to manufacturers and sub-contractors for the proper execution of all tests at their works as per contract specifications.

J. Tests At Manufacturer's Works

I. All tests to be performed during manufacture, fabrication and inspection shall be agreed with the Consultant/ Owner's site representative prior to commencement of the work. The Contractor shall prepare the details of the schedule and submit these to the Consultant/ Owner's site representative 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 Consultant/Owner's site representative who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections.

II. A minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Owner's site representative by the Contractor (whether the tests be held at the Contractor's of Sub-contractor's works). The subject items should remain available for Owner's site representative inspection 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 Owner's site representative to carry out the necessary inspection and testing of the Plant.

III. No plant 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 Owner's site representative or approved for shipment, or alternatively inspection has been waived.

IV. 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 Owner's site representative 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.

V. The Consultant/Owner's site representative 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 to date.

VI. 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 Owner's site representative.

VII. These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Owner's site representative 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.

VIII. 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 from complete with index and four copies of each volume shall be supplied to Consultant/ Owner's site representative.

IX. Stage wise inspection of equipment in factory in waived.

K. Performance Tests At Manufacturer's Woks

i. 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.

ii. Fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% over speed for 5 minutes 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.

iii. The Contractor shall submit single line diagrams including the layout of the Plant together with the location of test instrumentation and the principal dimensions of the lay-

Copyright © Buro Happold Limited

out. 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 Owner's Site Representative.

iv. 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 Consultant/ Owner's site representative.

v. 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.

3.9 IDENTIFICATION & LABELLING

A. **Color Scheme**

Description	Standard and Reference	Lettering Colouring
Exposed duct Work	To architect's	
Air-Conditioning Duct Work	BSS 111 Pale Blue	Black
Ventilation Duct work	BSS 111 Pale Blue	Black
Conditioner Casings, Fan Coil Units, Filter Plenums	BSS 111 Pale Blue	Black
Electrical (Conduit Ducts and Motors)	BSS 557 Light Orange	Black
Drains	Black	White
Beltguards	Black and Yellow diagonal stripes (45 25 mm wide)	
Switchboards - Exterior / Interiors	BS 366 Light Beige White	
Machine Bases, Inertia Bases and Plinths	Charcoal Grey	

B. Identification Of Services For Piping Services

Lubricating	14 E 53
Drainage and Other Fluids:	Basic Colour Only

Copyright © Buro Happold Limited

Electrical Services:	Basic Colour Only

In addition to the color bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows :-

Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

Pipe Line Contents	**BS.4800 Colour Reference**	**Colour**
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Color Code indicator bands shall be applied as color bands over the basic identification color in the various combinations as listed below

Pipe Line Contents	**Colour Bands to BS.4800**
Cooling	00 E 55
Condensate	04 D 45 /14 E 53 /04 D 45

C. **Duct Work Services:**

For Duct work services and its insulation the colors of the triangles shall comply with BS .1710:1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than150 mm length per side. One apex of the triangle shall point in the direction of airflow.

Services	**Colour**	**BS.4800 Colour Reference**
Conditioned Air	Red and Blue	04 E 53 / 18 E 53
Ward Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Re circulated Air	Grey	AA 0 09
Cold Supply Air	Blue	18 E 53

In addition to the color triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service ,identified as follows:-

Supply Air	S
Return Air	R

Copyright © Buro Happold Limited

Fresh Air	F
Exhaust Air	E

The color banding and triangles shall be manufactured from self adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

3.10 TESTING, ADJUSTING AND BALANCING

A. Scope

a. Testing, adjusting and balancing of Apartment heating, ventilating and air-conditioning systems at site.

b. Testing, adjusting and balancing of HVAC DX system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : 2007 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

B. 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.

C. Definitions

a. Test : To determine quantitative performance of equipment.

b. Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)

c. Balance : To proportion within distribution system (sub mains, branches and terminals) in accordance with design quantities.

D. 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 PMC about his readiness to conduct the TAB procedures in the format given in these specifications.

E. Description Of System And Requirements

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

a. All supply, return and outside air systems.

F. Air Systems

I. HI-wall Split / Ductable indoor Units Performance

The TAB procedure shall establish the right selection and performance of the indoor units with the following results :

a. Air-IN DB and WB temperature.(degree Fahrenheit)
b. Air-OUT DB and WB temperature.(degree Fahrenheit)
c. Dew point air leaving. (degree Fahrenheit)
d. Sensible heat flow.(Btu/hr)
e. Latent heat flow.(Btu/hr)
f. Sensible heat factor.
g. Fan air volume.(cfm)
h. Fan air outlet velocity.(fpm)
i. Fan static pressure.(in wg)
j. Fan power consumption.(kw)
k. Fan speed.(rpm)

II.Air distribution

Both supply and return air distribution for each indoor units and for areas served by the indoor units shall be determined and adjusted as necessary to provide design air quanti-

Copyright © Buro Happold Limited

ties. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

III. 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 :

a. All outside air intake, return air and exhaust air dampers are in proper position.
b. All system volume dampers and fire dampers are in full open position.
c. All access doors are installed & are air tight.
d. Grilles are installed & dampers are fully open.
e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.
f. All windows, doors are in position.
g. Duct system are of proper construction and are equipped with turning vanes and joints are sealed.
h. Test holes and plugs for ducting.

G. Readiness For Commencement Of Tab

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

H. Tab Instruments

I. Air Measuring Instruments

a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make Veloci Calc 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.
b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
c. Pitot tube.
d. Electronic Rotary Vane Anemometer TSI make or equivalent.
e. Accubalance Flow Measuring Hood TSI make or equivalent.

[All above instruments shall have a valid certification from a reputed testing institution.

II. Rotation Measuring Instrument

Electronic Digital Tachometer.

IV. Temperature & RH Measuring Instrument

TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

V. Electrical Measuring Devices

a. Clamp on Volt ammeter.
b. Continuity Meter.

VI. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each indoor units / outdoor units 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 PMC.

Sound level readings shall be taken at ten (10) locations in the building as selected by the PMC. 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 test shall be performed in the presence of PMC/Consultant.

Copyright © Buro Happold Limited

I. Testing & Commissioning of Lift well Pressurization System-

1) As the name implies, the intent is to prevent smoke from migrating into the elevator shaft by pressurizing the shaft with respect to the rest of the building. Typically the pressure differentials are created by actively controlling dedicated supply fans and isolation dampers (if applicable) to supply the elevator shaft with 100% outdoor air.

Pre functional checklist items include, but are not limited to, the following:

a) Fan systems and isolation dampers (if applicable) are installed per contract documents and manufacturer's installation instructions.

b) Control system point-to-point checkout complete to ensure all fan and damper input/output points are wired correctly.

c) Normal power, and emergency if applicable, is provided to each fan and damper assembly at proper voltage.

d) All fan systems have been balanced per the contract documents.

e) All safeties and interlocks, especially fan status and high pressure cut-out, are installed and function per contract documents.

2) Typically, isolation dampers will open (if applicable) and supply fan will be commanded ON automatically upon an event signal. In order to test proper operation of the elevator shaft pressurization system, initiate an event signal and verify the following:

a) All isolation dampers open (if applicable) and supply fans turn ON.

b) The pressure differential exceeds the value required by code. (Measure and record pressure differential across each elevator door with all doors closed.) Note that stack effect; wind speed and direction; and outdoor temperature may all influence measured pressures and system balance.

3.11 STATUTORY AUTHORITIES TESTS AND INSPECTIONS

A. As and when notified in writing or instructed by the client/ consultant, the contractor shall submit shop drawing and attend all tests and inspections carried out by Local Authorities and other Statutory Authorities shall forthwith execute free of charge any rectification work ordered by the client/ consultant as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

B. The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

C. The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the client/consultant for checking before submission. The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within six months after the award of the Contract but not less than six weeks before the inspection. The client/consultant may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

D. The Contractor shall notify the client/consultant at least seven days in advance of his application for local Authority tests and factory inspections / visits for major equipments.

On receipt of a confirmed date for test and inspection the Contractor shall inform the client/consultant without delay.

Copyright © Buro Happold Limited

3.12 PRELIMINARY COMMISSIONING CHECKS

A. Ensure that all equipment & system is thoroughly cleaned, lubricated and checked for serviceability before setting to work. Particular attention is drawn to the removal of building debris from the pipe work systems.

B. Special attention is drawn to the need for thoroughly flushing out all pipe work systems to ensure that all foreign matter is removed.

C. All automatic controls and safety devices shall be inspected and checked for service ability before the working fluid or electricity is applied to the system.

3.13 COMMISSIONING

A. When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all system in the entire installation. Special attention shall be paid to the following items:

1. That all valves, switches, controls, etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.
2. That all apparatus is silent in accordance with the requirements of this Specification.
3. That all instruments are correctly calibrated and read accurately.
4. That all services are tested in accordance with the details in the relevant clauses of this Specification.

3.14 FINAL ACCEPTANCE TESTS

A. Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final acceptance tests in accordance with a programme to be agreed with the client/consultant.

B. Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance is obtained.

C. Where acceptance tests are required by the relevant Authorities having jurisdiction, these tests shall be carried out by the Contractor prior to the issue of Completion Certificate to the acceptance of the Authorities.

3.15 REJECTION OF PLANT

A. Any item of plant or system or component which fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected by the client/consultant either in whole or in part as he considers necessary/appropriate. Adjustment and/or modification work as required by the client/consultant so as to comply with the Authority's requirements and the intent of the Specification shall be carried out by the Contractor at his own expense and to the satisfaction of the Authority/client/consultant.

B. After works have been accepted, the Contractor may be required to carry out assist in carrying out additional performance tests as reasonably required by the Employer.

3.16 HANDING OVER OF DOCUMENTS

A. All testing and commissioning shall be done by the Contractor to the entire satisfaction of the Client and all testing and commissioning documents shall be handed over to the Client.

B. The Contractor shall also hand over all maintenance and operation manuals, all certificates and all other documentation as per the terms of the contract to the Client.

3.17 MAINTENANCE DURING DEFECTS AND LIABILITY PERIOD (DLP)

A. General

1. Provide the following free maintenance for a period of Eighteen (18) months after handing over the HVAC System to client (i.e. during warranty period)

Copyright © Buro Happold Limited

2. Examinations: Bi-Weekly, including adjustments, cleaning and lubrication of equipment.
3. Replacement: Replace components when required, using parts produced by original manufacturer.
4. Spare Parts: Provide necessary spare parts; maintain locally an inventory of all wearing parts of the system.
5. Call Backs: Provide 24-hour emergency call back service at no expense to Owner.
6. Records: Maintain complete maintenance records including check charts, lubrication logs and activity logs; provide check charts and activity logs.

B. Extended Service Contract

1. At time of Bid, submit cost for full maintenance contract i.e. after the expiry of 18 month warrantee and free maintenance period.
2. Contract Term: Upon expiration of new installation, free maintenance, provide full maintenance service for five (5) years, including spare parts. Optional price for the maintenance to be provided for each year.
3. Service: Provide examinations, logs, replacements and spare parts as specified for maintenance, including cleaning of tanks, equipment and machinery spaces required to maintain the water output quality and quantity as per design.

END OF PART 3

Copyright © Buro Happold Limited

GUARANTEE PROFORMA

GUARANTEE FOR APARTMENT-HVAC SYSTEM INSTALLATION

We hereby guarantee the year round Apartment- HVAC System which we have installed in the building described below :

Building : ARANYA – NORTH TOWER

Location : Byculla, Mumbai

Owner : M/s Piramal

For a period of **18 Months** from the date of acceptance of the total installation, WE AGREE TO repair or replace to the satisfaction of the Owner, any or all such work that may prove defective in workmanship, equipment or materials within that period, ordinary wear and tear and unusual abuse or neglect excluded, together with any other work, which may be damaged or displaced in so doing. In the event of our failure to comply with the above mentioned conditions within a reasonable time, after being notified in writing, we collectively and separately, do hereby authorize the Owner to proceed to have the defects repaired and made good at our expense, and we shall pay the cost and charges thereof, immediately upon demand.

WE ALSO HEREBY UNDERTAKE to test the entire installation in first SUMMER, WINTER AND MONSOON on following the completion of the installation, to check and do everything necessary to ensure that the specified design conditions and functional requirement are met, that system is properly balanced, that all controls are calibrated accurately, and that all units are functioning satisfactorily.

SIGNATURE OF CONTRACTOR
For Apartment HVAC SYSTEM

DATE

SEAL

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – C & D

SCHEDULE OF EQUIPMENTS

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
Volume 02	B.1	HANGERS AND SUPPORTS		
		PART 1 - GENERAL		
		1.1	SUMMARY	1
		1.2	PERFORMANCE REQUIREMENTS	1
		1.3	SUBMITTALS	2
		1.4	QUALITY ASSURANCE	3
		PART 2 - PRODUCTS		
		2.1	PIPE HANGERS	4
		2.2	FLOOR SUPPORTS	5
		2.3	WALL SUPPORTS	5
		2.4	VERTICAL PIPING SUPPORTS	5
		2.5	DISTRIBUTION PIPING IN SHAFTS AND CHASES	6
		2.6	PIPE ANCHORS	6
		2.7	HANGER RODS AND ACCESSORIES	7
		2.8	BUILDING ATTACHMENTS	8
		2.9	SUPPORT INSULATORS	8
		2.10	TRAPEZE PIPE HANGERS	8
		2.11	METAL FRAMING SYSTEMS	8
		2.12	THERMAL-HANGER SHIELD INSERTS	9
		2.13	FASTENER SYSTEMS	9
		2.14	PIPE STANDS	10
		2.15	EQUIPMENT SUPPORT	10
		PART 3 - EXECUTION		
		3.1	HANGER AND SUPPORT INSTALLATION	13

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
VOLUME 02	B.1	3.2	PIPEWORK SUPPORT SPACINGS	13
		3.3	ADJUSTING	17
		3.4	CLEANING AND PAINTING.	17

Copyright © Buro Happold Limited

PART 1 - GENERAL

1.1 SUMMARY

A. Contractor shall allow for design , fabrication, installation and coordination with other trades for hangers, supporting system and expansion joints(for expansion joints refer section B.3) for the installed system

B. Section Includes:

1. Pipe hangers, Floor & wall supports, Vertical piping supports
2. Distribution piping in shaft and chases
3. Pipe anchors
4. Hanger rods and access**o**ries
5. Building attachments and support insulators
6. Trapeze pipe hangers.
7. Metal framing systems.
8. Thermal-hanger shield inserts.
9. Fastener systems.
10. Pipe stands.
11. Pipeline Anchors & Guides.
12. Equipment supports.
13. Steel ropes & wires

1.2 PERFORMANCE REQUIREMENTS

A. Design: Design hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7 or BS EN 13480.

C. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

D. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

E. The hangers and supporting system for the building shall be take care of the following effects

a. Seismic Movements(Earthquake case)
b. Effect of Wind - Building swing (Wind case)
c. Building settlement
d. Expansion and contraction
e. Column shortening for any given floor(including effects of creep and shrinkage)

Copyright © Buro Happold Limited

F. Following data to be used while designing the hangers and supporting

a) ***Lateral Displacement***

Floor	***Earth quake case***		***Wind Case***	
	X-DIRN		***Y-DIRN***	
	Maximum (mm)	***Interstorey (mm)***	***Maximum (mm)***	***Interstorey (mm)***
ROOF	*267*	*4*	*535*	*10*
LEVEL 49	*177*	*4*	*360*	*10*
LEVEL 30	*96*	*4*	*195*	*10*
LEVEL 11	*31*	*3*	*62*	*5*
BASEMENT-1	*0.1*	*0*	*0.3*	*5*

b) **Settlement Of the Building-**

Maximum Deflection *12* *mm*

Minimum Deflection *0* *mm*

Note: Success full bidder / contractor shall verify the above data with structural engineer before proceeding for the designing / selection of hangers and supporting system.

c) Column shortening for any given floor(including effects of creep and shrinkage) shall be 3mm floor Minimum.

1.3 SUBMITTALS

A. Contractor shall submit following calculations for hangers and supporting system for Consultant's review, Calculations shall be prepared and sealed by a qualified Structural Engineer and shall show compliance with the loading requirements. Furnish engineering calculations including, but not limited to, the following items.

1. Hanger design criteria
2. Point loadings.
3. Wall and column attachments.
4. Embedment's for supporting for all horizontal and vertical piping.
5. Stresses and forces on mountings and hangers from expansion and contraction of piping.
6. Engineering calculations to demonstrate compliance with requirements as specified in clause 1.2-E and 1.2-F above.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show fabrication and installation details and for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.
5. Detail fabrication and assembly of trapeze hangers.
6. Design Calculations.

D. Welding certificates.

Copyright © Buro Happold Limited

1.4 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel." Alternatively comply with BS 2971.

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code. Alternatively comply with HVCA code of practice TR/5, skilled craftsmen up to class 2 standard are required.

C. Clevis or Band Hangers used for sprinkler system piping shall be UL listed and labeled.

D. Unless otherwise stated, all steel components shall be galvanized post manufacture, according to ASTM B633 SC3.

E. Test certificate for heat aging at 1200C, as per ASTM D2240, shall be furnished for EPDM gasketting used as separation between pipe and hangers.

F. Each hanger and support shall have the manufacturer’s name and part number stamped on it.

G. All hangers and supports shall be manufactured at an ISO 9001 certified facility. Manufacturer’s ISO certificate, clearly stating Pipe Supports within the scope of registration, shall be furnished.

Copyright © Buro Happold Limited

PART 2 - PRODUCTS

2.1 PIPE HANGERS

A. Piping up to DN 50 (2 inch): Adjustable galvanised steel band hangars. Copper plated or EPDM LINED hangers shall be used piping.
Reference - ISHRAE Installation guide,Type-10, 7

B. Ferrous piping up to DN 150 (6 inch): Adjustable galvanised steel clevis hanger. Galvanised steel pipe covering shield shall be used for insulated piping, especially for HVAC services (alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide Type-1

C. Ferrous piping over DN 150 (6 inch) - HVAC Services: Adjustable, steel pipe roll with steel axle, steel sockets, lock nuts etc. Rubber support inserts and galvanised steel insulation protection shield shall be used at support points on insulated piping.
Reference - ISHRAE Installation guide Type 44

D. Copper piping (non-insulated): Adjustable swivel ring galvanised steel band hanger with EPDM lining.
Reference - ISHRAE Installation guide,Type-10, 7

E. Copper piping (insulated): Adjustable swivel ring galvanised steel band hanger with steel pipe covering shield (alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide,Type-10, 7

F. Plastic piping up to DN 150 (6 inch): Split ring type EPDM lined steel pipe clamp with welded suspension nut.
Reference - ISHRAE Installation guide,Type-10, 7 with rubber strips

G. Multiple hangers for pipes up to DN 75 (2 inch): Electro galvanized U-strap pipe clamps. with elastomer lining placed on painted / galvanised steel angle / channel suspended from ceiling.
Reference - ISHRAE Installation guide Type-1

H. Multiple Hangers for Combination of services: Hot dip galvanised steel, continuous channels cast-in in concrete or suspended from ceiling. Pipe hanger / supports shall be as specified before (make appropriate selection).

2.2 FLOOR SUPPORTS

A. Ferrous piping up to DN 150 (6 inch): Adjustable pipe stanchion saddle support complete with U-bolt, stand pipe with adjuster and floor flange, use galvanised steel pipe covering shield for insulated piping.(alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide Type-37

B. Ferrous piping over DN 150 (6 inch): Steel pipe roll with steel base and stand. RCC / structural steel pedestals shall be provided, as appropriate, to locate the base. Rubber support inserts shall be installed at support points to prevent crushing of insulation. Galvanised steel insulation protection shield shall be used outside rubber support inserts on roller based supports.
Reference - ISHRAE Installation guide Type-37, 44

Copyright © Buro Happold Limited

C. Copper piping (non-insulated): Adjustable pipe stanchion saddle support complete with rubber lined U-Bolt, stand pipe with adjuster and floor flange.
Reference - ISHRAE Installation guide Type-37

D. Copper piping (insulated): Adjustable pipe stanchion saddle support complete with U-bolt, stand pipe with adjuster and floor flange and galvanised steel pipe covering shield. Rubber support inserts shall be installed at support points to prevent crushing of insulation, as appropriate.
Reference - ISHRAE Installation guide Type-37

E. Plastic piping Same as that of ferrous piping.

2.3 WALL SUPPORTS

A. Multiple hangers for plumbing pipes up to DN 75 (2 inch): Electro galvanised U-strap pipe clamps with elastomer lining placed on painted / galvanised steel channel attached to wall.
Reference - ISHRAE Installation guide Type-12

2.4 VERTICAL SHAFT PIPING SUPPORTS

A. Ferrous piping up to DN 150 (6 inch): Galvanised steel riser clamps and / or offset pipe clamp. Rubber support inserts shall be used at the supports for insulated piping.

B. Ferrous piping over DN 150 (6 inch): Designed and fabricated at site with the following components:

1. Gusset plates with integral bearing plates (minimum thickness equal to that of the pipe) welded to pipe
2. Cross channels resting on permanent construction (floor slab / block work); offset to accommodate piping insulation and attached to each other by steel flats welded at both ends
3. `Z' cleats welded on the cross channels at the ends of the bearing plates to restrict movement
4. Heavy duty vibration isolation pads (50 durometer) placed under bearing plates for vibration / thermal isolation
5. Vapour barrier sealed around the gusset plate with mastic sealant

C. Plastic / copper non-insulated piping up to DN 75: U-bolts with rubber sleeve / or U-strap clamps with rubber lining attached to hot dip galvanised channel sections anchored to wall.
Reference - ISHRAE Installation guide Type-12

D. Plastic / copper piping over DN 75 (3 inch) - Non-insulated: Galvanised steel offset riser clamp with EPDM lining; resting on steel sections

E. Plastic / Copper piping over DN 75 (3 inch) - Insulated: Galvanised steel offset riser clamps over rubber support inserts installed at support points to prevent crushing of insulation.

F. Plastic piping: Zinc coated clip with internally threaded neck, sleeve, back nut, coach (wood) screw and plastic wall insert

Copyright © Buro Happold Limited

2.5 DISTRIBUTION PIPING IN SHAFTS AND CHASES

A. Copper piping: Semi circular galvanized steel straps with ears for attaching to walls.

2.6 PIPE ANCHORS

A. Shall be provided in suitable locations to control the direction and effects of movement of the pipework systems and to resist stresses and loading on pipework due to forces acting on the pipework system. Use materials similar or compatible with the pipework systems. Comply with the requirements of BS EN 13480-3.

B. Ensure structure is suitable for the transmitted stress.

C. Provide guides in accordance with the expansion joint manufacturer's requirements. Ensure that movement of pipework is directed from anchor points towards loops and bellows and ensure thrust is along the line of the pipework. Provide a friction reducing material between adjacent metal surfaces subject to movement.

D. The anchor and guide components shall be of suitable size and design to withstand and transfer the pipeline thrust. They shall be constructed to the general requirements of BS 13480.

E. The anchor loads, anchor and guide locations, method of fixing to the structure and design details shall be submitted and reviewed prior to commencement of the works.

F. Where bellows are used the manufacturer's recommendations shall be submitted for review and strictly adhered to.

G. Thrust blocks and suitable anchors shall be provided where pipework internal pressures are not contained by the jointing system.

H. Install guides on each side of axial expansion joints. The first primary guide shall be located within a distance of 4 pipe diameters or 300mm, whichever is the less. The second primary guide shall be located within a distance of 14 pipe diameters from the first guide. Where axial expansion joints are positioned next to an anchor the maximum distance shall be 4 pipe diameters or 300mm, whichever is the less

I. Ferrous piping (Horizontal, non-insulated): Galvanised steel anchor chair and U-bolt attached to structural steel framework.

J. Ferrous piping (Horizontal, insulated): Gusset plates (minimum thickness equal to that of the pipe) welded to pipe and bolted to structural steel frame. Vapour barrier shall be sealed around the gusset plate with mastic sealant.

K. Ferrous piping (Vertical, non-insulated): Steel U-Bolt fixed to steel channel. The bolt shall be back welded to the pipe after installation.

L. Ferrous piping (Vertical, insulated): Same as the support of vertical insulated ferrous piping over DN 150 (6 inch); excluding the vibration isolation pad. The bearing plate shall be welded or bolted down to the cross channel.

M. Copper piping (Horizontal): Galvanised steel anchor chair and U-Bolt over rubber support inserts all round, attached to structural steel frame work.

N. Copper piping (Vertical): Galvanised steel offset riser clamps, over rubber support inserts all round.

O. Plastic piping (Horizontal): Galvanised steel anchor chair and U- bolt attached to structural steel framework.

P. Plastic piping (Vertical): Steel U-Bolt fixed to steel channel.

Copyright © Buro Happold Limited

Q. Anchor / Thrust block
   1. Contractor shall provide suitably designed anchor blocks in cement concrete/steel support to cater to the excess thrust due to water hammer and high pressure
   2. Thrust blocks shall be provided at all bends, tees and such other location as determined by the Employer representative.
   3. Exact location, design, size and mix of the concrete blocks/steel support shall be as shown on the drawings or as directed by the Employer representative prior to execution of work

2.7 HANGER RODS AND ACCESSORIES

A. Galvanised steel hanger rods: Galvanised mild steel rods with continuous male thread.

B. Turnbuckles: Galvanised, malleable iron castings with female threaded ends, matching with the threaded hanger rods, shall be provided where required. Back nuts shall be provided on both sides of the turnbuckle after adjustment.
Reference - ISHRAE Installation guide Type-13

C. Threaded rod couplers: Galvanised steel unit machined from bar stock for joining two lengths of threaded hanger rods. Back nuts shall be provided on both sides of the coupler.
Reference - ISHRAE Installation guide Type-13

2.8 BUILDING ATTACHMENTS

A. Concrete inserts: Malleable iron or galvanised steel concrete inserts complete with adjustable insert nut, suitable for hanger rods of size 22 mm (7/8 inch) diameter and under. Galvanised steel continuous concrete insert shall be provided at the Contractor's option.

B. Self -drilling type concrete inserts: Galvanised steel self drilling expansion type concrete inserts for hanger rods up to 12 mm (½ inch) dia., shall be provided at the Contractor's option.

C. Support rails (cast-in type): Electro-galvanised steel sections with anchor lugs and filler strip, complete with hammer head nut or extension pieces.

D. Support rails (surface mounted type): Electro-galvanised steel sections complete with hammerhead nut or extension pieces. The rail shall be single or double as appropriate.

E. Inserts and Expansion bolts:

   1. Furnish and set inserts in concrete forms.
   2. Concrete inserts shall be as follows: Black malleable iron universal type for threaded connections with lateral adjustment for pipe sizes up to 200mm.
   3. For pipes 200 mm and over or equivalent group of pipes on trapeze, use two or more inserts to prevent exceeding maximum loading.
   4. As an alternative to the above mentioned inserts the Contractor may use expansion bolts. If the Contractor uses expansion bolts, the maximum spacing between supports may need to be reduced so as not to exceed the maximum loading and the expansion bolt locations shall be determined in coordination with the structural elements.

Copyright © Buro Happold Limited

2.9 SUPPORT INSULATORS.

1. The Contractor shall provide moulded hard rubber insulators at all supports of insulated pipework to transmit pipe load to hangers (or supports) without crushing the insulation. The rubber density shall not be less than 1100 kg/m3 and operating temperature range shall be -20 deg C to 110 deg C. The thickness of insulators shall be same as the insulation, and vapor barrier (where specified) shall be continuous across the outside of the insulators.

2.10 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel, G.I hanger rods, nuts, saddles, and U-bolts(Rubber lined). Alternatively comply with BS EN 13480-3 section 13

2.11 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following as per manufacturers list attached with tender documents.

   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with inturned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
   7. Metallic Coating: Electroplated zinc or Hot-dipped galvanized
   8. Paint Coating: Epoxy or Polyester.
   9. Plastic Coating: Polyurethane, Epoxy or Polyester

2.12 THERMAL-HANGER SHIELD INSERTS

A. Provide shields where required, to protect insulation at areas of contact with hangers and supports.

B. Brackets on pipework which is insulated shall have proprietary made heavy density phenolic foam (with zero ODP) circular rings or flat sections, of equal thickness to the insulation, inserted between the bracket and pipe or duct.

C. The inserts shall incorporate a factory applied metal spreader plate and a Class 0 vapor barrier. The length of the insert shall extend outside the bracket by at least 15mm each side.

D. Where pipework expansion takes place on roller chairs, the insert shall extend the full expansion distance plus 15mm and an outer galvanized sheet steel casing of suitable thickness shall be secured to the insert to prevent damage.

E. On pipework systems operating at elevated temperatures the inserts shall be suitable for the operating conditions.

F. Vapor barriers shall be continuous over the inserts and in the case of roller chairs, under the outer galvanized sheet casing.

G. Pipework insert density is to be as follows:

Pipe size (mm)	Density (kg/m³)
Up to 100	80
Over 100	120

H. Inserts for HTHW and steam services shall be constructed from calcium silicate.

Copyright © Buro Happold Limited

I. Insert Length: Extend 50 mm beyond sheet metal shield for piping operating below ambient air temperature.

2.13 FASTENER SYSTEMS

A. Verify suitability of fasteners in this article for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.

B. Supports shall be solidly fixed to the structure using proprietary manufactured drill and plug fixing devices with removable bolt or screw. Wooden plugs, loose fill or masonry nails will not be allowed. Gun fixings will only be allowed when specifically approved.

C. At each support fixing a steel channel or angle iron section shall be secured to the structure from which pipework, ductwork supports and brackets and equipment supports shall be attached.

D. Holes in steelwork supports and brackets shall be formed by correctly drilling, using the recommended tolerances for that which is to be inserted. Flame gun / welding torch holes burned out will not be allowed.

E. Where individual pipes up to 50mm diameter are supported on timber or lightweight walls, ceilings or partitions, brackets shall be of the screw fixing type and primary channel or angle iron brackets shall not be used. On solid / heavy walls over 100mm thickness, individual pipework may be supported by the use of built-in, long shank holder bats or pipe brackets.

F. Supports from the building structural steelwork shall be made using proprietary manufactured steel clamps or girder lugs. Direct drilling of the structural steelwork will not be allowed.

G. Where high level pipework and equipment cannot be supported from the structure, a primary Galvanized steelwork supporting frame shall be provided, fixed to the floor and of suitable design to spread the load evenly, from which all pipework and equipment shall be supported.

H. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

I. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

J. Use largest size of bolt, screw to suit diameter of hole in equipment to be fixed. Ensure that fixings are tested for tensile loading to BS 5080, this particularly applies to expanding anchors.

K. Plastic plugs of suitable size and length shall be used. Use screws to BS 1210. For fixing to concrete, brickwork or block work use sheradized steel wood screws but in damp or exposed situations use greased brass screws.

L. Obtain approval if shot fired fixings are proposed.

2.14 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece GI base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: G.I
3. Vertical Members: Two or more G.I continuous-thread rods.
4. Horizontal Member: G.I rod with plastic or stainless-steel, roller-type pipe support.

Copyright © Buro Happold Limited

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.15 Equipment Support

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

PART 3 - EXECUTION

3.1 HANGERS AND SUPPORT INSTALLATION

A. Pipework support systems shall be supported from the building structure, generally conforming with the following and where specified elsewhere:

- BS EN 13480-3 Metallic Industrial Piping. Design and Calculation
- MSS SP 58, Pipes, hangers and supports- Materials Design and Manufacturer
- MSS SP 69, Pipes, hangers and supports- Selection and Application
- Manufacturer’s recommendations in respect of plastic pipe.
- EJMA Standards for expansion joints
- Uniform Mechanical Code
- Seismic Restraint Manual for Mechanical Systems.

B. Pipework supports are to be arranged so that minimum stress is imposed upon the pipelines or ductwork. Additional supports are required on either side of equipment such as valves, strainers, and the like on pipework. It is important to ensure that all materials used for pipework supports are compatible with the pipeline materials.

C. The details shown elsewhere indicate brackets, and support details which may be acceptable subject to the application but the final working details, drawings or sketches shall be submitted for Review.

D. Rigid coupling may be used with IPS steel piping systems, which meet the support and hanging requirements of ASME B31.1 and ASME B31.9. An adequate number of grooved flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe and column shortening due to creepage & shrinkage.

E. INSERTS

- Inserts shall be provided to relevant Sections for placement in concrete formwork for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- Hooked rod shall be provided in concrete for inserts carrying pipe over DN 150 (6 inch).

Copyright © Buro Happold Limited

- Where concrete slabs form finished ceiling, inserts shall be installed flush with the slab soffit.
- Where inserts are omitted due to error, the slab shall be drilled through from below and through bolt with square steel plate and nut above shall be provided, recessed into and grouted flush with slab.
- Type and quality of expansion type anchors, where used, shall be selected to suit the concrete into which it is to be installed.

F. Hanger or support assembly shall be capable of taking up the filled weight of piping for half spans on either side plus 100 kg, with minimum overall factor of safety of two.

G. Hangers shall be installed with minimum 12 mm (½ inch) space between finished covering and adjacent work.

H. Hanger shall be placed within 300 mm (12 inch) of each horizontal elbow.

I. Hangers shall have a minimum vertical adjustment of 38 mm (1½ inch).

J. Multiple or trapeze hangers shall be provided where several pipes can be installed in parallel and at same elevation.

K. Riser piping shall be supported independently of connected horizontal piping.

L. Piping shall be supported on both sides (at the system side only on connections to equipment) of flexible connections.

M. No support, hanger or anchor shall be attached to the building structural elements wherein their installation, weight or expansion stress will result in damage to the structure.

N. One coat of zinc rich primer shall be applied, after scraping and brushing the area clean, to the weld and surrounding areas, where pipe support members are welded to building structural framing.

O. Piping buried in raft slabs or trenches shall be supported as detailed on the Contract drawings. The support shall be capable of holding the pipe in position against buoyant forces exerted during pouring of concrete.

P. Pipework supports are to be arranged so that no undue stress is imposed upon the pipes.

Q. The installer will be responsible for marking out the exact positions where pipe brackets are to be built in and for checking the accuracy, levels and alignment of supports after building in by others.

R. All vertical pipes shall be fixed by galvanized clamps and galvanized angle brackets truly vertical.

S. Branch pipes shall be connected to the stack at the same angle as that of the fittings. No collars shall be used on vertical stacks.

T. Horizontal pipes running along ceiling shall be fixed on galvanized adjustable type clamps of special design as directed and as required.

U. Horizontal pipes shall be laid to uniform slope and the clamps adjusted to the proper levels so that the pipes fully reset on them.

V. Contractor shall provide all sleeves, openings, hangers, inserts during the construction. He shall provide all necessary information to the building contractor for making such provisions in the structure as necessary. All damages shall be made good to restore the surfaces.

W. All pipes clamps, supports and hangers shall be galvanized. Factory made prefabricated clamps shall be preferred.

X. Contractor may fabricate the clamps of special nature (at the discretion of the clients representative) and galvanize them after fabrication but before installation. All nuts, bolts, washers and other fasteners shall be factory galvanized.

Y. Frames shall be of approved design and fabricated from MS flats (which shall be galvanized after fabrication) of thickness and sizes as per contractor's approved shop drawings.

Copyright © Buro Happold Limited

Z. Clamps shall be fixed in accordance to manufacturer's details/shop drawings to be submitted by the contractors.

AA. When required to be fixed on RCC columns, walls or beam they shall be fixed with approved type of galvanized expansion anchor fasteners (Dash fasteners) of approved design and size according to load.

BB. Structural clamps e.g. trapeze or cluster hangers shall be fabricated by electro-welding from MS structural members e.g. rods, angles, channels flats as per contractors shop drawings shall be galvanized after fabrication. All nuts, bolts and washers shall be galvanized and shall be ready made item from a reputed supplier.

CC. Galvanized slotted angle/channel of approved sizes supports on walls shall be provided wherever shown on approved shop drawings.

DD. Angles/channels shall be fixed to brick walls with bolts embedded in cement concrete blocks and to RCC walls with anchor fasteners mentioned above. The spacing of support bolts on support members fixed horizontally shall not exceed 1 m.

EE. All G.I Brackets should be painted with anti rust coat prior being embedded in concrete at the time of civil work itself.G.I Brackets as shown in approved shop drawings.

FF. Pipework supports shall not exceed the maximum intervals as per manufacturer's recommendation. However the sagging of the installation will not be accepted..

GG. Additional supports shall be provided for equipment such as valves, strainers and ancillaries so that minimum stress is imposed on the pipework and the weight is not taken by the pipework. The support arrangement shall allow safe operation and removal of the component.

HH. All brackets and supports shall allow free movement of the pipes due to expansion and contraction with special regard to prevention of damage to any thermal insulation and vapour barrier. Fixed supports and roller/guide flexible support at appropriate locations to be provided to accommodate pipe movement due to thermal expansion/contraction and column shortening at every floor due to creepage , shrinkage and lateral displacement (wind and earth quake case and building settlement).

II. Where multiple pipe runs of differing bores are supported from a common point, use support spacing of pipe requiring the closest spacing with adequate provision for the unequal movement due to expansion and contraction. Supports shall also be provided at bends where there is a run of pipework 1 metre or more both sides of the bend.

JJ. Cantilever type supports from walls will not be allowed except for single pipes of diameters up to 50 mm.

KK. Obtain approval for all fixings to structural concrete or structural steelwork and loads imposed on the structure. Shot fired fixings shall not be used or any reinforcement drilled through.

LL. Static point loadings transferred to the structure which cannot be accommodated by the structural fixings shall be spread over a larger area by means of additional brackets and/or additional load spreading primary steelwork.

MM. For vertical support spacing check total self-weight and pressure loading against manufacturer's recommendations when using mechanical joints or end load capable flexible couplings. Ensure adequate support when using non-end load capable flexible couplings.

NN. Direct clipping of the pipes, conduits or cables to the wall or the ceiling or any other structural members shall not be allowed.

OO. In case the supports are to be taken from the block work than the contractor shall clearly identify the locations for the solid block or lintels.

PP. In case of dry wall partions only conduits and small pipes (50mm plastic pipes) can be supported from the drywall partion frame (any extra support location shall be clearly defined) . in case of a heavy material purpose built steel frame shall be provided by the MEP trade contractor.

QQ. The area which is crowded for the services installation; MEP contractor shall coordinate among themselves and design the support according to loads which will supported from the same supports.

Copyright © Buro Happold Limited

RR. MEP Contractor is not allowed to cut any support of the drywall partition frame. This shall be coordinated on site with dry wall partition vendors before the start of the work.

SS. All the Suspended equipment and system components support shall be based on the dynamic loading of the equipment and supporting shall be designed accordingly.

3.2 PIPEWORK SUPPORT SPACINGS

A. Provide pipework supports such that the maximum intervals listed below are not exceeded.

B. Table 1 applies to Pressurised Pipework listed below:

- Steel - BS EN 10255, BS EN 10217, BS EN 10216-1
- Schedule 40, Schedule 30
- Copper - BS EN 1057
- Cast Iron - BS 4622
- Ductile Iron - BS EN 545, BS EN 598 and BS EN 969

TABLE 1

Nominal PIPE BORE (mm)	MAXIMUM SUPPORT SPACING (m)					
	STEEL PIPE		COPPER PIPE		IRON PIPE	
	horizontal	vertical	horizontal	vertical	horizontal	vertical
Up to 15	1.8	2.4	1.2	1.8	-	-
20	2.4	3.0	1.4	2.1	-	-
25	2.4	3.0	1.8	2.4	-	-
32	2.7	3.0	2.4	3.0	-	-
40	3.0	3.6	2.4	3.0	-	-
50	3.0	3.6	2.7	3.0	1.8	1.8
65	3.7	4.6	3.0	3.6	-	-
80	3.7	4.6	3.0	3.6	2.7	2.7
100	3.7	4.6	3.0	3.6	2.7	2.7
125	3.7	5.4	3.0	3.6	-	-
150	4.5	5.4	3.6	4.2	3.7	3.7
200	5.0	6.0	-	-	3.7	3.7

Copyright © Buro Happold Limited

250	5.0	6.0	-	-	4.5	5.4
300	6.1	10.0	-	-	8.0	10.0
350	10.0	12.0	-	-	-	-
400	10.5	12.6	-	-	-	-
450	11.0	13.2	-	-	-	-
500	12.0	14.4	-	-	-	-
600 and above	14.0	16.8	-	-	-	-

Note: For refrigeration pipework 15 - 28mm support copper pipework on continuous plastic coated cable tray.

C. Table 2 - Applies to Plastic Pipework listed below:

- Polythene - BS EN 13244
- Polythene - BS EN 12201
- ABS - BS 5391
- PVC-U - BS EN ISO 1452

TABLE 2

PIPE BORE (mm) Nominal	MAXIMUM SUPPORT SPACING (m)			
	UPVC PIPE & ABS PIPE		POLYETHYLENE/PB PIPE	
	Class O,B,C,	Class E, 6,7	BS EN 12201	BS EN 13244
Up to 10	-	0.6	0.3	0.45
15	-	0.6	0.4	0.6
20	-	0.65	0.4	0.6
25	-	0.75	0.4	0.6
32	-	0.8	0.45	0.7
40	-	0.9	0.45	0.7
50	1	1	0.55	0.85
65	1.2	1.2	0.55	0.85
80	1.2	1.2	-	0.9
100	1.3	1.3	-	1.1
125	1.5	1.5	-	-
150	1.6	1.6	-	1.3
175	1.7	1.8	-	-

Copyright © Buro Happold Limited

200	1.9	2	-	-
225	2	2	-	-
250	2	2	-	-
300	2.4	2.4	-	-
350	2.4	2.4	-	-
400	2.4	2.4	-	-
450	2.4	2.4	-	
above 450	2.4	2.4	-	

Note:

Class O	-	*(Non pressure)*	*Class B*	-	*6.0 Bar*
Class C	-	*9.0 Bar*	*Class D*	-	*12.0 Bar*
Class E	-	*18*	*Class 6 & 7*	-	*pressure varies refer to BS*

- For plastic pipework in Table 2 the vertical spacing may be a maximum of 1½ times the horizontal spacing.
- For UPVC and ABS pipework reduce spacing if operating at temperatures above 20°C in accordance with manufacturers requirements for temperature above 60°C provide continuous supports.

D. Table 3 -Applies to Pressure Polypropylene Pipework

TABLE 3

TABLE 3 POLYPROPYLENE TO BS EN ISO 15874-1			
PIPE OUTSIDE DIAMETER mm	MAXIMUM SUPPORT SPACING (m)		
	20°C	60°C	100°C
20	0.6	0.5	0.4
25	0.7	0.6	0.5
32	0.8	0.7	0.6
40	0.9	0.8	0.7
50	1.0	0.9	0.8
63	1.2	1.0	0.9
90	1.3	1.2	1.0
110	1.5	1.3	1.1

Copyright © Buro Happold Limited

E. Table 4 - Applies to Sanitation and Rainwater Pipework listed below

- Iron Piping BS EN 877
- PVC-U Pipes BS EN 1329-1, BS 4514
- Polypropylene BS EN 1451-1
- Vulcathene (Polypropylene)

TABLE 4

PIPE BORE (mm) Nominal	MAXIMUM SUPPORT SPACING (m)					
	UPVC & Polypropylene		Vulcathene		Iron Piping	
	horizontal	vertical	horizontal	vertical	horizontal	vertical
20	-	-	-	-	-	-
25	-	-	-	-	-	-
32	0.5	1.2	-	-	-	-
40	0.5	1.2	1.2	1.5	-	-
50	0.9	1.2	1.4	1.5	1.5	3.0
63	-	-	-	-	-	-
80	0.9	2.0	1.5	1.5	1.5	3.0
100	1.0	2.0	1.8	1.5	1.5	3.0
125	-	-	-	-	1.5	3.0
150	1.0	2.0	1.8	1.5	1.5	3.0
175	-	-	-	-	-	-
200	-	-	-	-	1.5	3.0

Copyright © Buro Happold Limited

3.3 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Support Adjustment: Piping and equipment shall be brought to the proper level by providing grout under the supports.

C. Trim excess length of continuous-thread hanger and support rods to 15 mm.

3.4 CLEANING AND PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.

B. Apply paint by brush or spray to provide a minimum dry film thickness of 0.05 mm.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair (Zinc rich) paint to comply with ASTM A 780.

3.5 HANGERS & SUPPORTS FOR ELECTRICAL SYSTEM :

A. SCOPE :

The specifications given below relates to the testing & supplying support system for busducts, busbars, conduits, cable trays, cable ladders in schedule of quantities at Site:

The scope of work shall include Transporting, loading / unloading the hanger & support system to project site, storing, handling, shifting, installing, testing and commissioning for all the items reflecting in Bill of Quantities & layouts,

B. SUPPORT, ANCHORAGE & ATTACHEMENT COMPONENTS :

1. **Steel Slotted Support Systems:** Factory-fabricated components for field assembly.
   a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to IS Standards.
   b. Non-metallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied.
   c. Painted Coatings: Manufacturer's standard painted coating applied.
   d. Channel Dimensions: Selected for applicable load criteria.
2. **Non-metallic Slotted Support Systems**: Structural-grade, factory-formed, glass-fibre-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches.
3. **Fittings and Accessories:** Products of channel and angle manufacturer and designed for use with those items.
4. **Rated Strength:** Selected to suit applicable load criteria.
5. **Conduit and Cable Support Devices:** Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
6. **Support for Conductors in Vertical Conduit:** Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armoured electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported.
7. **Structural Steel for Fabricated Supports and Restraints:** ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

Copyright © Buro Happold Limited

8. **Mounting, Anchoring, and Attachment Components**: Items for fastening electrical items or their supports to building surfaces include the following:

   a. **Powder-Actuated Fasteners:** Threaded-steel stud, for use in hardened cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   b. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      - Hilti Inc.

   c. **Mechanical-Expansion Anchors:** Insert-wedge-type, stainless steel, for use in hardened cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   d. **Concrete Inserts:** Steel or malleable-iron, slotted support system units similar to MSS Type 18

   e. **Through Bolts:** Structural type, hex head, and high strength. Comply with ASTM A 325.

   f. Toggle Bolts: All-steel springhead type.

   g. Hanger Rods: Threaded steel

C. APPLICATION :

1. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NEC 2011 and relevant IS codes. Minimum rod size shall be 1/4 inch in diameter. Supports shall be selected based on loading as per manufacturers recommendation. Support for busduct including sway movement, seismic and expansion joint.
2. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
3. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2inchand smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

D. SUPPORT INSTALLATION :

1. Raceway Support Methods: In addition to methods described in relevant IS / NBC codes supports may be supported by openings through structure members (any such proposal must be first submitted by the Contractor as a technical submittal for approved by the project Structural engineer.
2. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs (91 KG).
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

   a. To Wood: Fasten with lag screws or through bolts.

   b. To New Concrete: Bolt to concrete inserts.

   c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

   d. To Existing Concrete: Expansion anchor fasteners.

   e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

Copyright © Buro Happold Limited

f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

g. To Light Steel: Machine screws.

h. To GI steel: GI screws shall be permitted.

i. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

j. To Light Steel: Sheet metal screws.

k. Items Mounted on Hollow Walls and Non-structural Building Surfaces: Mount cabinets, panel boards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

l. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. INSTALLATION OF FABRICATED METAL SUPPORTS :

1. Comply with installation requirements for site-fabricated metal supports.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
3. Field Welding: Comply with AWS D1.1/D1.1M.

F. CONCRETE BASES :

1. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
2. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
3. Anchor equipment to concrete base.
   a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   b. Install anchor bolts to elevations required for proper attachment to supported equipment.
   c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

G. PAINTING :

1. **Touch up:** Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.
2. **Galvanized Surfaces:** Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
VOLUME 02	B.2	NOISE, VIBRATION AND SEISMIC CONTROL		
		1.1	GENERAL	1
		1.2	QUALITY ASSURANCE	2
		1.3	SUBMITTALS	2
		1.4	VIBRATION CONTROL	2
		1.5	INSTALLATION AND TESTING	7

Copyright © Buro Happold Limited

1.1 GENERAL

A. This section relates to the prevention of unwanted vibration transmission from mechanical and electrical items of equipment to sensitive areas inside and outside the building.

B. Fabricate, assemble, deliver to site and install vibration control measures to meet the performance standards specified.

C. All intermediate mechanical plant room shall have necessary vibration isolation in supporting system as well as in installation.

D. In seismic control areas provide anti vibration mountings suitable for the zonal classification of the area

E. Note the requirement to reselect vibration control equipment to suit the final actual operating weights and speed of operation of plant.

F. The Contractor shall refer and comply with all the applicable requirements indicated in acoustic consultant's reports/ recommendations.

G. The Contractor shall be responsible for ensuring that the acoustic performance of the equipments meets the design criterion described in the relevant sections of the project specification at the date of equipment procurement.

H. The Contractor shall furnish the complete acoustic report of the equipment prior to start of the procurement procedure.

I. Provide flexible connections to all pump suction and Discharge connection, Air cooled chillers & OAHU's. For detail product specification

J. Provide Rubber mounts for indoor DX and VRF Condensing units.

K. Following Noise criteria table to be followed:

S.NO	LOCATION	NOISE LEVEL
1	Parking	NC-60+
2	Plant room	NC 55-65
3	Retail	NC-45
4	Offices	NC-35
5	Business center	NC-35
6	Multipurpose room	NC-35
7	Spaces within 3m of shaft take offs	NC-40
8	Bathrooms	NC-45
9	Corridors	NC-45
	RESIDENCES:	
1	Nightime: AC unit low speed	NC-30
2	Daytime: AC unit medium speed	NC-35
	AMENITIES:	
1	Tenant gym	NC-40
2	SPA	NC-35/40

Copyright © Buro Happold Limited

1.2 QUALITY ASSURANCE

A. Ensure that the design, construction, materials and finishes of all equipment are suitable for the location, climatic and operating conditions to which the installation will be exposed.

B. Ensure that the whole installation complies with the relevant standards, including the following:

- BS 4800 - Schedule of paint colours for building purposes
- BS 6472-1 - Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting
- BS 4718- Methods of tests of silencers for air distribution system
- ASHRAE equipment and system Handbook-2008
- BS EN ISO 9001- Quality management system requirements.
- IS 1893 -Criteria for Earthquake resistant design of structures.
- SMACNA DW144
- ASTM-E477- Standard test method for Measuring acoustical and airflow performance of duct liner materials and prefabricated silencers.
- ISO-7235- Guide to evaluation of human exposure to vibration in buildings, vibration sources other than blasting
- ISO 5135- Determination of sound power levels of noise from air terminal devices.
- AMCA 300 & 301- Reverbant room method for Sound testing of fans/Methods for calculating ban sound ratings from LAB test data.
- NEBB- National Environmental Balancing bureau.
- CIBSE B5- Noise and Vibration control for HVAC.

1.3 SUBMITTALS

A. Provide a fully documented set of the calculations upon which the vibration equipment has been selected.

B. Contractor shall submit the typical details of equipments with the vibration isolations details as per acoustic consultant's requirement.

1.4 VIBRATION CONTROL

A. Vibration Isolators - General

1. Supply and install vibration isolators as indicated on the vibration isolation schedules and also wherever necessary to limit vibration transmission into the building structure, supporting structure, pipework or ductwork, Chiller , Pump's, AHU's, Fan's, Transformer's, DG sets , FCU's , Indoor AC units, VRF/VRV equipment's etc.
2. Ensure that any vibration transmitted from the mechanical and electrical services installations into the building structure does not exceed the 83dba at 1.5m distance.
3. Ensure that the maximum vibration amplitudes specified in BS 6472-1 or ASHRAE guidelines are not exceeded.
4. Select vibration isolators so that they are suitable for the loading, operating and environmental conditions which will prevail. Pay special attention to vibration isolators exposed to atmospheric or adverse interior conditions and apply appropriate finishes to prevent corrosion.
5. The static deflection of vibration isolators shall be selected to give the necessary degree of isolation efficiency under the lowest normal operating speed of the isolated plant. Selection shall allow for asymmetric load distribution such that the minimum static deflection is achieved on all vibration isolators under normal operating conditions. All machines and bases shall be carefully levelled. Replace any vibration isolators which are "bottomed out" or where the springs have deformed from a cylindrical shape at no extra cost to the contract.
6. All vibration isolators shall be colour coded or otherwise clearly marked to indicate rated load and deflection capacity to facilitate identification during installation.

Copyright © Buro Happold Limited

7. All external connections to vibration isolated plant shall be made using flexible connections. Particular care shall be taken to ensure that the connection of pipes, ducts, shafts, electrical conduit etc., to vibration isolated plant neither short circuits the plant vibration isolation, nor impedes the free movement of the vibration isolated plant.
8. The vibration isolation system shall be selected to support the operating weight of the plant and equipment to be isolated only. All associated pipework, valves, filters, ductwork etc., and their contents shall be supported independently so as not to impose additional forces on the isolator system. All flexible connections shall be selected and arranged to accommodate this requirement.
9. All plant, pipework and ductwork shall be resiliently isolated from any part of the building structure as specified, or as otherwise required, to achieve the specified noise and vibration criteria. Particular attention shall be paid to areas where low noise levels are specified. The mounting of any item of plant, pipework (bigger than 50mm plastic pipes) or ductwork from lightweight (stud) partitions is not permitted.
10. Select spring mounts with an overload capacity of 50% and with an outside diameter of at least 75% of the operating height. Mark mounts permanently with load capacity.

B. Vibration Isolation Plant and Equipment

1. Unless otherwise stated, plant and equipment isolators shall be provided as indicated on the following schedules. For specification of isolator types refer to the following clauses. Isolators must be selected for the operating weight of equipment and shall be positioned for equal deflection.
2. Unhoused Spring Mounts (Type S)

   Provide where indicated on the vibration isolation schedule unhoused spring mounts. The mountings shall comprise of free standing, unhoused, laterally stable steel spring with a top and bottom load plate and leveling bolt.
3. Vertically Restrained Spring Mounts (Type L)

   Provide where indicated on the vibration isolation schedule vertically restrained spring mounts. The mountings shall comprise high strength; low stress helical steel and springs capped with steel pressure plate on neoprene base pad. Supply base plate pre-frilled for bolting down and painted for protection. Supply unit complete with lockable leveling device to limit the vertical movement.
4. Pre-Compressed Moulded Glass Fibre Mounts (Type F)

   Provide where indicated on the vibration isolation schedule pre-compressed moulded glass fibre mounts. The mountings shall be composed of inert inorganic material covered with an elastomeric coating to increase damping and protect the glass fibres. The isolation pad shall be bonded to a steel load transfer washer and formed steel bolt down bracket and shall include a steel bolt with a neoprene grommet.
5. Spring Compression Hangers (Type H)

   Provide where indicated on the vibration isolation schedule spring hanger mountings. In addition spring hangers shall be used to support all pipework and ductwork connected to rotating and reciprocating machinery within plantroom areas or within 15 m of the plant which ever is the lesser.

   When used for supporting pipework and ductwork the springs shall have a minimum deflection of 25mm unless otherwise stated.

   The hangers shall comprise of a steel spring or glass fibre pad or a combination of both retained in a welded steel bracket. The steel spring shall be free standing, unhoused and laterally stable having horizontal spring stiffness equal to or greater than 1.3 times the vertical stiffness. The hanger bracket shall be designed to carry five times overload without failure and shall allow up to 15mm dia rod misalignment without metal to metal contact.
6. Kinetic Neoprene Mounts (Type N)

Copyright © Buro Happold Limited

Provide where indicated on the vibration isolation schedule Kinetic neoprene isolators. The moulded neoprene isolators shall be complete with a cast in tapped steel load plate to permit bolting to supported equipment and a cast in steel anchor base plate pre-drilled for holding down bolts. The neoprene shall be oil and corrosion resistant.

7. Inertia Bases (Type S-I)
   Provide where indicated on the vibration isolation schedule inertia bases manufactured from welded steel channels designed to receive concrete poured into the steel frame. The steel frame shall incorporate pre-located equipment anchor bolts and free-standing laterally stable spring mounts generally as described under type S mounts.

8. Inertia Bases (Type L-I)

   Provide where indicated on the vibration isolation schedule inertia bases generally as type S-I except that the springs shall be type L vertically restrained.

9. Inertia Bases (Type F-I)

   Provide where indicated on the vibration isolation schedule inertia bases generally to type S-I except that the isolators shall be moulded glass fibre isolators as described under type F mounts.

10. Steel Base Frames (Type S-B)

    Provide where indicated on the vibration isolation schedule steel frame bases manufactured from structural steel members incorporating isolator mounting brackets and supported by free standing spring isolators as described under type S mounts.

11. Steel Base Frames (Type L-B)

    Provide where indicated on the vibration isolation schedule steel beam bases manufactured from structural steel members incorporating isolator mounting brackets and supported by vertically restrained spring isolators as described under type L mounts.

C. FLEXIBLE CONNECTIONS-GENERAL

1. Flexible connections shall be fitted to all Pump Suction and Discharge connections, Chillers Condensers and other centrifugal reciprocating or vibrating equipment where it is marked on the drawing, and where anti-vibration mounts, inertia bases are fitted.
2. Flexible Connections must have been tested for Noise and Vibration reduction capabilities, with due Certification being submitted to the Engineer for approval prior to the order being placed.
3. Flexible Connections are to be fitted as close to the source of vibration as practicable. The pipe at the other end of the Flexible Connection is to be a fixed point. This is necessary to reduce the noise, vibration and resonances from the distribution pipework to the building fabric, and prevent any stresses in the pipework from being transmitted upon the pump or vibrating equipment. To ensure correct alignment, a spool piece is to be employed during installation.
4. Rubber Flexible Connections shall be single convolution of hand laid multi ply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be removable and suitably profiled to control the convolution shape; plate flanges must not be used.
5. To avoid over tightening and damaging the sealing face of the rubber bellows the flanges shall be designed to make metal to metal contact with its mating flange when fully tightened.
6. Threaded and adjustable tie bars with rubber top hat washers shall be used where the working pressure exceeds 1.5 bar g. When untied Flexibles are used, the manufacturer's recommendations for anchors and guides shall be followed to prevent forces being exerted on to the pump casing and AV mounts.
7. All flexible connections shall be compliant with the PED (Pressure Equipment Directive) and be stamped with the CE mark.

D. RUBBER TYPE FLEXIBLE CONNECTORS HIGH TENSILE SYNTHETIC FIBRE REINFORCED TYPE FOR TEMPERATURES UP TO 70°C

Copyright © Buro Happold Limited

1. For working temperatures up to 70°C the bellows carcass shall be reinforced using high tensile synthetic fibre.
2. Manufacturer: 1) Engineering Appliances Limited, 2) Kinetics 3) Resistoflex 4) systemflex or similar approved.

E. RUBBER TYPE FLEXIBLE CONNECTORS STEEL WIRED REINFORCED TYPE FOR TEMPERATURES 70-100°C

1. For working temperatures between 70°C and 100°C the Flexible carcass must be steel wire mesh reinforced throughout to prevent catastrophic failure, as nylon reinforcements do not provide the system security and safety required at these temperatures. The Rubber Flexible Connections are to have a minimum design life of 10 years, continuously operating at 100°C and then have a minimum burst pressure of 30 bar g, in compliance with the minimum requirements of DIN 4809-1. An up to date and valid compliant certificate must be provided. The approval number shall be vulcanized into the rubber and coincide with that shown on the certificate.
2. The flexible bellows shall be fully traceable: and moulded into the carcass shall be the manufacturer, country of origin, type and batch number, serial number, and the date of manufacture.
3. Manufacturer: Engineering Appliances Limited STENFLEX type AS EA53, EA51-untied/EA58, EA52 -tied. (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

F. STAINLESS STEEL TYPE FLEXIBLE CONNECTORS FOR TEMPERATURES ABOVE 100°C

1. For temperatures above 100°C Flexible Connection must not be manufactured from Rubber, but shall be of stainless steel thick wall spirally wound multi-ply construction to provide the required noise and vibration reduction. The flexible shall be 130mm long and provided with Van Stone ends and swivel flanges. This type of Flexible Connection being for installations where the pump is on “solid” AV mounts
2. Manufacturer :(1) Engineering Appliances Limited type Epsilon EA46/49 (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

G. FLEXIBLE CONNECTORS FOR USE WITH EQUIPMENT ON SPRING TYPE SUPPORTS

1. For installations where the pump and/or pipe work is on spring type supports, the flexible shall be as indicated above(rubber of stainless steel), but shall be a lateral type unit with a double membrane to give greater flexibility for this type of installation.
2. Manufacturer: (1) Engineering Appliances Limited type EA23 (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

H. FLEXIBLE HOSES

1. Provide where indicated on the drawings or as required. Rubber type has limited life and temperature. Rubber type not suitable for potable water services. Stainless steel type not suitable for elevated chlorine levels in excess of 200ppm.
2. Rubber type: Comprise unreinforced 3mm thick EPDM rubber liner with a stainless steel braid. Fittings are swaged using AISI 304 stainless steel ferrules suitable for design temperatures -10°C to 100°C. Manufacturer: 1) Engineering Appliances Limited (2) Kinetics (3) Resistoflex (4) systemflex or similar approved.
3. Stainless Steel type: Comprise longitudinally welded thin wall stainless steel (AISI 321) convoluted tube with stainless steel (AISI 304) braid. Fittings to suit pipework size and material. Suitable for temperatures 100 – 130°C. Manufacturer: Engineering Appliances Type EA71 & EA 73 (2)Kinetics (3) Resistoflex (4) systemflex or similar approved.

I. Vibration Isolation Schedule

Equipment	Equipment location

Copyright © Buro Happold Limited

type	Basement		Ground or up to 6m floor span		9m floor span		12m floor span		15m floor span	
	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)
Refrigeration machines										
Air or refrigeration compressors up to 750 rpm	S	25	S-B	38	S-I	62	S-I	62	S-I	69
Air or refrigeration compressors over 750 rpm	S	25	S	25	S-I	38	S-I	62	S-I	69
Pumps										
Close coupled up to 7.5 kW	N *	9	N	9	S-B	25	S-B	25	S-B	25
Close coupled over 7.5 kW	S-I *	19	S-I	25	S-I	38	S-I	62	S-I	62
Base mounted and belt driven up to 7.5 kW	F-I *	9	F-I	9	S-I	38	S-I	44	S-I	62
Base mounted and belt driven over 7.5 kW	S-I *	25	S-I	25	S-I	44	S-I	62	S-I	88
Generators Engines										
up to 18 kW	F-I	9	F-I	9	S-I	44	S-I	62	S-I	62
19-99 kW	F-I	9	S-I	44	S-I	62	S-I	88	S-I	88
100 kW and over	S-I	25	S-I	62	S-I	88	S-I	127	S-I	127
Axial Fan and Low Pressure Centrifugal Fans (Up To 75mm) and Air Handling Units										
Suspended units (up to 4 kW)	H	19	H	25	H	25	H	25	H	25
Suspended units over 4 kW up to 500 rpm	H	32	H	32	H	32	H	44	H	62
Suspended units over 4 kW and over 500 rpm	H	25	H	25	H	25	H	32	H	44
Floor mounted units (up to	N	9	S	25	S	25	S	25	S	25

Copyright © Buro Happold Limited

Equipment type	Equipment location									
	Basement		Ground or up to 6m floor span		9m floor span		12m floor span		15m floor span	
	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)
4kW)										
Floor mounted units over 4 kW (up to 500 rpm)	N	9	S-B	44	S-B	44	S-B	44	S-B	62
Floor mounted units over 4 kW (over 500 rpm)	N	9	S	25	S	25	S-B	38	S-B	44
High Pressure Centrifugal Fans (Over 750 N/m²) and Air Handling Unit(Floor Mounted)										
up to 15 kW (up to 300 rpm)	N	9	S-B	62	S-B	62	S-B	88	S-B	127
up to 15 kW (301-500 rpm)	N	9	S-B	44	S-B	44	S-B	62	S-B	88
up to 15 kW (501 rpm and up)	N	9	S-B	25	S-B	25	S-B	44	S-B	62
over 15 kW (up to 300 rpm)	N	9	S-B	62	S-I	88	S-I	127	S-I	140
over 15 kW (301-500 rpm)	N	9	S-B	44	S-I	62	S-I	88	S-I	127
over 15 kW (501 rpm and up)	N	9	S-B	25	S-I	44	S-I	62	S-I	88

*** NOTE: For Fire Protection Pumps, there will no Inertia bases and pumps will be mounted on PCC blocks with anti vibration rubber mounts.**

1.5 INSTALLATION & TESTING

A. Provide installation and testing of complete ductwork systems.

B. Carry out commissioning tests in accordance with this specification.

C. Demonstrate at commissioning stage, to the satisfaction of the Clients representative, that all specified vibration levels have been achieved.

D. When installing anti-vibration mountings comply with manufacturer's instructions.

E. Level equipment to ensure loads are evenly distributed.

F. Protect all equipment from damage by ingress of water or dirt.

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
Volume 02	B.3	EXPANSION FITTINGS AND LOOPS		
		PART 1 - GENERAL		
		1.1	SUMMARY	1
		1.2	PERFORMANCE REQUIREMENTS	1
		1.3	SUBMITTALS	2
		1.4	QUALITY ASSURANCE	2
		PART 2 - PRODUCTS		
		2.1	EXPANSION SYSTEMS	3
		2.2	EXPANSION LOOPS GENERAL	3
		2.3	EXPANSION LOOPS - STEEL	3
		2.4	MECHANICAL EXPANSION JOINTS	3
		2.5	UNRESTRAINED EXPANSION JOINTS	4
		2.6	RESTRAINED EXPANSION JOINTS	4
		2.7	PIPELINE ANCHORS AND GUIDES	4
		2.8	SERVICES CROSSING BUILDING EXPANSION JOINTS	4
		2.9	FLEXIBLE CONNECTIONS DETAILS	5
		PART 3 - EXECUTION		
		3.1	EXPANSION-JOINT INSTALLATION	5
		3.2	INSTALLATION	7

Copyright © Buro Happold Limited

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Expansion Loops.
2. Mechanical Expansion Joints
3. Unrestrained Expansion Joints.
4. Restrained Expansion Joints.
5. Alignment guides and anchors.
6. Flexible Connections

1.2 PERFORMANCE REQUIREMENTS

A. Responsibility of Contractor:

1. Determine required system expansion, compensation, and location of all guides anchors and expansion devices using finalized contractor's installation drawings.
2. Design and provide expansion compensation devices, equipment and anchors.
3. Provide calculations by a licensed professional engineer substantiating that expansion compensation is designed to meet all system expansion requirements and safely accept generated forces without failure.
4. Coordinate expansion requirements with the work of other trades.
5. Provide structural engineer with required loads and forces required to support and restrain piping. Approval of these loads is required prior to pipework installation commencing.

B. Provide sufficient supports, fixing and pipework components in such a manner that expansion and contraction of the pipework is fully accommodated.

C. Generally movement shall be accommodated at all changes in direction and/or at terminations of pipework.

D. Branch connections or pipe junctions to main pipework shall be made with 2 Nr 90° changes in direction to form an offset of suitable length to facilitate the expansion/contraction and prevent excess strains on the pipework joints at the junctions.

E. Where expansion or contraction of pipework cannot be accommodated as described above expansion loops or mechanical expansion joints shall be provided.

F. The application, location and type of joints shall be in accordance with BS 6129-1.

G. Where expansion devices are installed the correct amount of "cold draw" must be applied and adequate provision shall be made for temporary clamps or spacer pieces during the testing operations defined elsewhere.

H. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures. Mechanical expansion devices and flexible connections used on water services piping shall be WRAS approved, or similarly approved for potable water systems by the local municipality.

I. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

J. Provide & Comply to lateral displacement (wind case & earthquake case) building settlement and column shortening (due to creepage and shrinkage) requirements specified in section B.1-clause E & F.

Copyright © Buro Happold Limited

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of expansion joint, from manufacturer.

E. Maintenance Data: For expansion joints to include in maintenance manuals.

F. Expansion joints calculation for vertical risers: Furnish movement calculation based on the following criteria:

1. Minimum creepage and shrinkage factor of 3mm per floor.
2. Thermal expansion and contraction
3. Lateral displacement(wind & earthquake case) & building settlement as specified in section B.1-clasue E & F

1.4 QUALITY ASSURANCE

A. Comply with the following:

- BS 13480-3 - Metallic industrial piping. Design and calculation
- BS 6129-1 - Code of practice for the selection and application of bellows expansion joints for use in pressure systems. Metallic bellows expansion joints
- EJMA "Standards of the Expansion Joint Manufacturers Association"

Copyright © Buro Happold Limited

PART 2 - PRODUCTS

2.1 EXPANSION SYSTEMS

A. Where possible provision for movement due to thermal expansion and contraction shall be made by natural changes in the direction of pipework. Provide expansion loops or mechanical joints if necessary.

B. Anchors and guides shall be positioned to contain all movement and resist the maximum loads imposed.

C. Anchors and guides are to be located at points which prevent excess stresses on pipework, joints and equipment connections.

D. Similar provisions shall be made for building movement or building settlement.

2.2 EXPANSION LOOPS GENERAL

A. Prefabricated expansion loops shall be constructed in the same pipework class and finish as the pipework system.

B. Where access is limited prefabricated expansion loops shall be used and only on pipework up to 65 mm.

2.3 EXPANSION LOOPS - STEEL

A. Provide expansion loop in the material and finish of the associated pipeline. The loop shall be sized to limit the total stress set up in the material of the pipe wall to less than 69 MPa. The Contractor shall supply calculations for approval by the engineer.

B. Bends shall be from a single length of pipe or by welding fittings if expansion loops are too large to manufacturer in the piece.

C. Drawings indicating the method of anchoring and guides shall be supplied to the engineer for approval.

D. The spacing of the supports shall not exceed the centres given in the pipework section. Where there are two or more pipes the spacings shall be based in the centres required by the smallest bore pipework.

E. Vertical rising pipework shall be supported at the base or, as required to withstand the total weight of the riser and thrust.

2.4 MECHANICAL EXPANSION JOINTS

A. Where natural flexing of the pipework is not practical thermal expansion and building movement shall be accommodated by the use of expansion joints.

B. Expansion joints may be of the restrained or unrestrained type and shall be provided with welded, screwed or flanged ends as appropriate.

C. Expansion joint convolutions shall be of a thick wall spirally wound, multi-ply construction with a corrosion resistant inner ply in AISI 316L stainless steel. Units should be fitted with stainless steel inner sleeves, in compliance with EMJA.

D. For critical services such as MTHW, HTHW and steam, the bellows must have a weep hole as a fail-safe device.

E. Expansion joints shall be capable of not less than 5000 complete reversals of movement at the given working conditions and the manufacturer shall be able to produce calculations to that effect, in full compliance with EJMA (Expansion Joint Manufacturers Association).

F. Expansion joints shall be capable of withstanding a test pressure 1.5 times the design working pressure without deformation. .

Copyright © Buro Happold Limited

G. Expansion joints and their corresponding anchors and guides shall be indicated on the shop drawings and shall be installed strictly in accordance with the manufacturer's instructions and guidelines.

H. All mechanical expansion joints shall be in accordance with BS 6129-1 or EJMA Standards by the expansion joints. They shall be provided with flanged or screwed ends to BS EN 1092-1 and BS EN 10226-1 or ANSI B16.3 and ANSI B16.1, respectively, as appropriate. They shall be manufactured from stainless steel appropriate to the working pressures of the various systems. They shall be supplied with external protective sleeves.

I. Grooved flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe and column shortening due to creepage & shrinkage.

J. The manufacturer's requirements shall be complied with and anchor loads shall be calculated and their proposed locations approved prior to commencement of the works. Where axial bellows are installed the manufacturer shall visit the site and inspect the final installation prior to cold pressure testing.

K. Lateral expansion joints are sometimes also called articulated or fully articulated. Angular expansion joints are sometimes referred to as hinged. For larger lateral movements in two planes two gimbal expansion joints may be used instead of the lateral unit. Restrained expansion joints are not designed to support associated pipework.

2.5 UNRESTRAINED EXPANSION JOINTS

A. Axial expansion joints shall only be used in positions where pressure thrust can be contained by adequate anchor points contained by the building fabric. Recommended guide spacings and tolerances as described in Engineering Appliances "Guide to the use of Expansion joints" are critical and must be strictly adhered to.

B. Axial expansion joints shall be as manufactured by Engineering Appliances Limited their type EA01, EA02EA04, EA06, EA07, EA08, EA15 and EA16 or equivalent approved.

C. Axial expansion joints are not restrained and will exert a pressure thrust. This load can be very high and needs to be contained by suitable anchors. Comply with BS 13480.

2.6 RESTRAINED EXPANSION JOINTS

A. Restrained expansion joints shall be used as an offset type either by using lateral or angular expansion joints to compensate for thermal expansion or building movement. The expansion joint restraints shall be designed to absorb the full pressure thrust of the expansion joint convolutions.

B. Lateral expansion joints shall be of the thick wall spirally wound multi-ply construction and fitted with threaded tie bars and low friction self-lubricating hemispherical nuts, allowing movement in two planes. Lateral expansion joints shall be as manufactured by Engineering Appliances Limited their type EA20, EA23 and EA24 or Equivalent approved.

C. Angular expansion joints shall be of the thick wall spirally wound multi-ply construction and be used in pairs or threes. All hinge pins shall be PTFE coated to reduce friction and prevent corrosion. Angular expansion joints shall be as manufactured by Engineering Appliances Limited their type EA31 and EA32 or Equivalent approved.

D. For movement in two planes Gimbal Expansion joints shall be used in pairs or in combination with one Angular Expansion joint. All hinge pins shall be PTFE coated to reduce friction and prevent corrosion. Gimbal expansion joints shall be as manufactured by Engineering Appliances Limited their type EA38 or Equivalent approved.

2.7 PIPELINE ANCHORS AND GUIDES

Refer section B.1- 2.9 for Pipeline anchors and guides.

2.8 SERVICES CROSSING BUILDING EXPANSION JOINTS

A. At points where services cross the building expansion joints flexible connections, compensators, or expansion joints shall be provided to accommodate the building movement within the services installation.

Copyright © Buro Happold Limited

B. Brackets and supports each side of the flexible joint shall be so arranged that services crossing the building expansion joint remain symmetrical and correctly aligned.

2.9 **FLEXIBLE CONNECTIONS**

Refer Section B.2- 1.4(12) for details.

EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install pipework so that stress is kept below the maximum permissible design stress as given in the appropriate pipework standard.

B. Prior to installation, submit to the consultant for approval the exact locations and working drawing details including magnitude and direction of thrusts of all expansion joints, guides, anchors and other associated equipment.

C. Connect to items of plant and equipment in such a way that no stress is placed on the equipment or its connections.

D. Do not use branch connections as anchor points.

E. Wherever possible, cater for expansion and contraction by the inherent natural flexibility of the service pipework. Where the use of inherent natural flexibility is not practicable, supply, install and connect expansion joints into the pipework installation.

F. Install expansion joints in full accordance with the manufacturer's recommendations and instructions.

G. Prior to commencement of the installation, the contractor must agree with the expansion joint manufacturer to visit site to ensure his guidelines for selection and installation are adhered to. And that the anchors and guides are correctly positioned to ensure that the expansion joints function as intended. During system installation and just prior to application of heat onto the systems, the expansion joint manufacturer is to visit site to check that the installation is installed as designed and a Certificate of Compliance issued.

H. Install expansion joints with a cold pull (cold draw) equal to 50% of total expansion, except where expansion joints are supplied with cold pull already applied. Apply cold pull (cold draw) by means of flanges secured to the ends of pipe to be pulled together with long high tensile steel bolts and nuts. A check with the design figure for correct gap plus allowance for gasket thickness shall be made before final pull is made. A change to standard bolting shall be made when the gap is closed. Do not apply cold pull (cold draw) until the anchor installations have been completed and approved by the Consultant / PM.

I. Install guides on each side of axial expansion joints. The first primary guide shall be located within a distance of 4 pipe diameters or 300mm, whichever is the less. The second primary guide shall be located within a distance of 14 pipe diameters from the first guide. Where axial expansion joints are positioned next to an anchor the maximum distance shall be 4 pipe diameters or 300mm, whichever is the less.

J. Provide intermediate guides for the remainder of the pipework at appropriate intervals.

K. Ensure that guides are capable of withstanding a lateral force of at least 15% of the anchor force.

L. Ensure that the lateral movement of the pipeline permitted by the guide is no more than 2mm (±1mm) for pipes up to 100mm nominal size and 4mm (±2mm) for larger pipes, for the two primary guides next to the expansion joint. For intermediate guides the movement should be no more than 4mm (±2mm) and 8mm (±4mm) respectively.

M. Where pipework up to 50mm size is fixed to solid walls, brackets may be of either the screw fixing type or long shank built-in type. For fixing to woodwork and lightweight partitions or walls, brackets shall be screw-on pattern and may be adjustable two-piece type.

N. Brackets for mild steel pipework shall be mild steel or malleable iron. Brackets for copper pipework shall be brass or gunmetal.

Copyright © Buro Happold Limited

O. Obtain approval from the Consultant/Project Manager for any fixings to structural concrete or structural steel work.

P. Fixings to the building structural element shall generally be by “Redheads”, rawl bolts clamps adaptors or similar approved heavy fixings and white metal rawl plugs or approved plastic type plugs for light loads. Drilling of structural steelwork shall not be used for pipe supports. Supports with backplate in floor screed shall not be used.

Q. Pipework shall be securely supported, singly or in groups, graded to levels required for venting and draining and having regard to the requirements for differential expansion, anchors and guides and thermal insulation sizing.

R. Pipework exposed to view shall have approved brackets or clips of neat appearance, screw fixed to the wall at intervals to give uniform spacings and neat appearance.

S. Non-ferrous clips and rollers shall be used on copper pipes or if steel clips are used lead packing sleeves shall be fitted between pipe and clip.

T. Mains in ducts shall be supported on rollers and chairs using fabricated mild steel brackets (painted) or galvanized channel sections with allowance for building-in or bolting-on to the surface of the duct wall.

U. Pipes at ceiling level or in roof spaces shall be suspended from rods or straps using adjustable mild steel hangers with swinging joints or purpose-made angle iron cradles or other steel sections. Clips shall be used on cold pipes with rollers and chairs on hot pipes and where expansion cannot be readily taken upon hanging brackets.

V. Exposed external steel brackets shall be fabricated then hot dipped galvanized before erection, unless otherwise specified.

W. Allowance for the fitting of pipe covering protection saddles specified shall be made at the support positions on mains that require continuous unbroken weatherproof or vapor proof seal finish, as in the case of chilled water or cold water pipes. Where required, fit load-bearing insulation at supports at the time of erecting this pipework.

X. Pipework of 65mm size and larger subjected to expansion and contraction and hung from supports shall be suspended on swivel hangers unless otherwise agreed with the client.

Y. Hangers for horizontal pipework at high level shall be supported from mild steel angle or channel sections or approved proprietary devices, suitable for building-in or otherwise securing to the structure. Adjustable mild steel hangers shall be used. Drop rods shall not be less than 13mm diameter. Pipe rings shall be of malleable cast iron or fabricated steel, made in halves and secured by bolts or screws. Alternatively, malleable iron hinged pipe rings may be used, but calliper hooks will not be permitted.

Z. Pipework supports shall be arranged so that minimum stress is imposed upon the pipelines. Provide additional supports on either side of pipework ancillaries and equipment such as valves, strainers, and heating coils and other pipeline mounted equipment. It is important to ensure that all materials used for pipework supports are compatible with the pipeline materials

AA. Installation of Flexible Grooved end expansion joints

1. Install in accordance with OEM Manufacturers instruction manual.

2 A OEM Factory trained field representative shall provide on- site training for contractor’s field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review to ensure contractor is following best recommended practices in grooved product installation. (A distributor’s representative is not considered qualified to conduct the training or jobsite visit(s).

- All mild steel supports and channels shall be replaced with GI or mild steel with Zinc coating

Copyright © Buro Happold Limited

3.2 INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-NMEJ-702 “Rubber Flanged Non-Metallic Expansion Joint. Installation, Maintenance and Storage”

E. Install grooved-joint expansion joints to grooved-end steel piping.

Copyright © Buro Happold Limited

FOR ELECTRICAL PART, PLEASE REFR TO THE ELECTRICAL TENDER SPECIFICATION

DOCUMENT ISSUED. – This section is only valid for all M and PH & FP specification

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE NO.
VOLUME - 02	B.5	TESTING & COMMISIONING		
		1.1	SUMMARY	1
		1.2	SCOPE OF WORKS	1
		1.3	QUALITY ASSURANCE	2
		1.4	SUBMITTALS	3
		1.5	FACTORY TESTS	4
		1.6	ON-SITE TESTING AND COMMISSIONING	5
		1.7	TESTING AND COMMISSIONING OF FIRE PUMPS AND ANCILLARIES	7
		1.8	TESTING AND COMMISSIONING OF WATER SUPPLY SYSTEM	8
		1.9	TESTING AND COMMISSIONING OF DRAINAGE SYSTEM	11
		1.10	TESTING AND COMMISSIONING OF HVAC SYSTEM	12
		1.11	STATUTORY AUTHORITES TEST AND INSPECTIONS	22
		1.12	PRELIMINARY COMMISSIONING CHECKS	22
		1.13	COMMISSIONING	22
		1.14	FINAL ACCEPTANCE TESTS	22
		1.15	REJECTION OF PLANT	23
		1.16	HANDLING OVER OF DOCUMENTS	23

Copyright © Buro Happold Limited

1.1 SUMMARY

A. Employ the services of an independent specialist commissioning subcontractor to programme, commission and collate test results.

B. The Contractor shall provide skilled technicians/engineer to commission the plant and associated controls to the satisfaction of the Owners representative.

C. Provide all necessary attendance to operate and maintain the plant and equipment during the commissioning period as required to suit the needs of the specialist commissioning contractor.

D. The technicians/ engineers will be required to demonstrate the correct procedures in starting and stopping the plant, running the various items of equipment under automatic and manual control and the correct maintenance of the plant.

E. This section provides a framework for the testing, regulation and commissioning procedures to be employed.

F. The scope of the works in this section may be divided into three stages:
- Pre-installation stage
- Installation stage
- Commissioning stage

G. Final approval of commissioning of the System / equipment is subjected to clearance of Local municipal corporation,CFO & LEED commissioning consultant.

H. The repetition of any test or commissioning shall be done if warranted by the Statutory Authority.

1.2 SCOPE OF WORKS.

A. Pre-Installation Stage

1. Ensure that sufficient valves, test points, dampers etc. are incorporated and correctly located to allow satisfactory testing, regulating and commissioning.
2. Ensure that all provisions for commissioning are included in the working drawings prior to being sent to the Owners representative.
3. Produce an agreed programme and method statements for the commissioning works for approval by the Owners representative.

B. Installation Stage

1. Undertake all tests and collate and witness all tests.
2. Ensure that all water systems have been properly cleaned, flushed, filled and vented.
3. Ensure that all air distribution systems have been properly cleaned and checked.
4. Prepare method statements for the commissioning of each system.
5. Attend the manufacturer's / supplier's works for performance tests on all major items of plant and equipment including, but not limited to, the following:
    a) MCCs
    b) Fire pumps
    c) Domestic & Grey water Pumps
    d) Drainage pumps
    e) Generators
    f) HV and LV switchgear
    g) HVAC Equipments
        - Air cooled chillers
        - Chilled water pumps
        - Outside Air handling units(OAHU)
        - Smoke and Ventilation fans

Copyright © Buro Happold Limited

- DX Indoor/Condensing units
- VRF Indoor/Condensing Units

h) FA system
i) Security system
j) BMS system
k) Lighting
l) Central Water heating system
m) Earthing & lighting protection
n) Solar water heater system
o) Fire proofing/Stopping

6. Collate all satisfactory test certificates for inclusion in the O&M manuals. Any plant or equipment that fails to meet the specified duty shall require to be replaced unless given authorization to do otherwise by the Owners representative.

C. Commissioning Stage

1. Commission the works in accordance with the commissioning programme.
2. Independently retest 10% of the electrical tests on all power and lighting circuits. Should the tests indicate an unacceptable level of error the whole system shall be re-tested.
3. Witness and accept the commissioning of all specialist systems by the manufacturers / suppliers including, but not limited to the following:
   a) Fire protection systems
   b) Fire alarm systems
   c) BMS systems
   d) PA system
   e) HV systems
   f) Security system
   g) Emergency lighting
   h) Emergency generator systems
   i) Air cooled chillers
   j) All Pumps
   k) Outside Air handling units(OAHU)
   l) VRF system
   m) Obstrusion lighting
   n) Central water heater system
   o) Solar water heater system
   p) Earthing & Lighting Protection.
   q) Car Park ventilation system
   r) LV Panels
   s) Transformers(if supplied by contractor)
   t) Bus bar
   u) Fire proofing.
4. Collate all testing and commissioning records for inclusion in the O&M manuals.
5. Demonstrate, to the satisfaction of the Owners representative, that the systems are properly regulated and set to work.
6. Ensure that all detectors, etc. are properly adjusted and calibrated and that all controls conditions are achieved. Ensure that all systems operate to their design intent including all safety, alarm and control scenarios.

1.3 QUALITY ASSURANCE.

A. The work content and contract programme shall be based on the recommended procedures set out in the following documents (hereafter called the “commissioning documents”):

1. CIBSE Commissioning Codes:
   a) CIBSE Code A: Air Distribution Systems
   b) CIBSE Code B: Boiler Plant
   c) CIBSE Code C: Automatic Control Systems
   d) CIBSE Code L: Lighting

Copyright © Buro Happold Limited

e) CIBSE Code R: Refrigerating Systems
f) CIBSE Code W: Water Distribution Systems

2. CIBSE Technical Memoranda:
   a) TM17: Building Services Maintenance Management
3. BSRIA Documents:
   a) BG1/2007: Operating and Maintenance Manuals for Building Services
   b) BG2/2010: The Commissioning of Water Systems
   c) AG3/89.3: The Commissioning of Air Systems
   d) AG1/91: Commissioning of VAV Systems in Buildings
   e) BSRIA AG17/2000: Achieving Minimum Outdoor Air: Commissioning and Test Procedures
   f) AG1/2001.1: Pre-Commissioning Cleaning of Water Systems
   g) AG9/2001: Standard Specifications for BMS
   h) AH3/92: Installation Maintenance and Commissioning of Fire and Security Systems
   i) BG11/2010: Commissioning Job Book
   j) TM1/88.1: Commissioning HVAC Systems (Responsibilities)
4. NEBB- HVAC Commissioning.

B. Undertake commissioning in accordance with all manufacturer's literature relating to the plant and equipment installed as part of the engineering services installations.

1.4 SUBMITTALS

A. Submit the following at the appropriate time for comment and review:
- Commissioning programme
- Commissioning method statements
- Testing and commissioning record sheets

B. Commissioning Programme

1. Within 2 weeks of appointment, provide a commissioning programme indicating the various activities and associated time periods required for the commissioning of the services. Agree this programme with the Owners representative and other relevant parties for incorporation into the main contract programme.
2. Take into account the contract programme and identify:

   The following periods:

   Pre-commissioning of water systems, electrical systems and HVAC System.
   Power on date
   Dynamic commissioning
   Performance demonstrations and witnessing
   Operation and maintenance manual
   Handover and employer's training

   The following for each system:

   Earliest and latest start date
   Finish date
   Duration to complete task (in days)

   The following milestones:

   Completion of static tests (pipework, ductwork and electrical tests)
   Period required for dynamic testing (balancing and integrated tests)
   Power on to the MCCs
   Cooling on to the building

Copyright © Buro Happold Limited

Demonstration to the Owners representative.
Submittals required to show building regulation compliance
Employers training
Practical completion

3. Ensure that all systems are shown separately and not grouped together, e.g. "MCC's" is not acceptable but "MCC1", "MCC2", etc. would be acceptable.
4. Each system shall be separately identified and all interdependencies shall be shown.
5. Indicate the period required for the fully integrated testing of the systems to demonstrate that all systems interact with each other in the correct manner. This is particularly relevant to fire alarm, BMS and any life safety items with hard-wired interlocks.
6. Carry out a major review and update of the commissioning network at monthly intervals thereafter, and if necessary revise and amend his programme to suit the progress of the works. Copies of the programme and network analysis together with any revisions shall be issued to the Owners representative for comment.

C. Commissioning Method Statements

1. Within 30 days of appointment, provide method statements for each system and sub-system for the whole works listing all the activities in complete detail for comment and approval by the Owners representative.
2. Identify the following:
   Specific details of the task
   Responsibilities of each party
   Any pre-requisites or milestones
   Interfaces with other systems
   Documentation proposed
   Health and safety considerations
   Demonstration procedures
3. No commissioning shall take place without an approved method statement being in place.

D. Testing and Commissioning Record Sheets

1. Submit testing and commissioning record sheets to the Owners representative for comment. Agree information and sheets to be used with the Owners representative Record information on agreed documentation and submit to the Owners representative for comment and review.

E. Co-Ordination

1. Co-ordinate the commissioning works with the works of others and assist as necessary.
2. Indicate on the drawings where access is required into ceiling voids and partitions and ensure that these points are available at the start of the commissioning works and are not closed up until the commissioning works are complete.

1.5 FACTORY TESTS

A. Main Switchboard

The following tests shall be performed in the presence of the Owners Representative.

1. Inspection of switchboard including wiring, electrical and mechanical connections.
2. Mechanical tests.

Copyright © Buro Happold Limited

3. Primary and secondary injection tests to commission and calibrate all measuring, protection and control circuits and associated components.
4. Continuity and dielectric tests.
5. Power frequency and pressure test.
6. Functional check of all control wiring.

B. Valves, Cocks and Fittings

1. Type-Test' and approval certificate for pressure test and compliance with the regulations laid down by the local Authority / Standards / Project Manager.

C. All major equipment's should be factory tested and contractor shall allow for factory visit for witnessing of client & consultant.

- Air Cooled Chillers
- OAHU's
- Pumps for all services.
- DX indoor/outdoor units.
- VRV indoor/outdoor units.
- Smoke and Ventilation fans.
- Jet/Induction fans
- Central water heaters.
- Solar water heaters.
- DG sets.
- Transformers.

1.6 ON-SITE TESTING AND COMMISSIONING - GENERAL.

A. The contractor shall allow sufficient time prior to completion of contract work, the Contractor shall liaise and submit for the client's approval a detailed programme for conducting on-site acceptance tests and commissioning.

B. The Contractor shall start up, operate, test and adjust the systems in accordance with the agreed programme. The setting shall be supervised by the manufacturer's representative, who shall remain on site until the equipment is operating satisfactorily and accepted by the Client. The Contractor shall advice and co-ordinate with the manufacturer's representatives so that all testing is carried out according to the agreed programme.

C. The whole installation shall be given the following tests to bring the systems into running order. The Client shall be given reasonable notice together with a copy of recorded test results, generally not less than seven (7) days, regarding the nature of tests, the time and location. Acceptance tests will only be witnessed by the Client when the submitted tests results are found satisfactorily.

D. All instruments, tools, material and labour required to perform these tests shall be provided by this Contractor.

E. Before the tests are carried out, the Contractor shall remove connected equipment and components which are liable to damage under test, and shall provide and fix all the necessary gauges, blanking flanges, etc.

F. Prior to the system start-up, the following inspection, tests and pre-commissioning treatment shall be carried out by the Contractor:

1. Tanks and Level Switches

Copyright © Buro Happold Limited

a. Check sides and edges of sectional tanks for distortion. The tanks shall be thoroughly cleaned with water and drained.
b. Also, the level switch shall be simulated for the various cut-in and cut-out settings.

2. Pressure Switches.
   a. The testing equipment arrangement for pressure switches and pressure gauges shall be as shown on the approved shop drawings.
   b. The pressure gauges to be tested shall be connected as shown on the approved shop drawing in lieu of the pressure switch. The gauges to be tested shall be regarded acceptable when the pressure readings of all three gauges are the same throughout the jacking pressure range varied by applying the hand pump.

3. Hydrostatic Tests
   a. All parts of the water circuit shall be filled with water before hydrostatic pressure testing, and pump running tests for verification of pressure and flow rate, are conducted.
   b. The hand-jacking pump shall be applied to increase the system pressure to 1.5 times the working pressure but in any case not less than 10 bar for water supply and 6 bar for drainage. The pressure shall be maintained for a period not less than 24 hours.
   c. Where any section of pipe work or equipment is found to be unable to withstand the maximum pipe work test pressure, it shall be isolated during the pipe work test then that section of pipe work or equipment shall be made good and re-tested at the appropriate test pressure.
   d. The working pressure for various systems shall be estimated by contractor and submit for approval to the consultant.
   e. All valves and accessories etc should be factory tested at 1.5 times of its design working pressure system

G. Drains

1. House drains shall be hydrostatically tested to a water head of 1.2 m at the high end and not more than 2.4m at the low end and shall show no appreciable loss of water after elapse of two hours.

2. In every test, water used shall be left in the pipes until they are covered with earth or other trench filling material to a depth of at least 1 m over the top of pipes and until permission is given by the client/consultant for the water to be released. If after the client/consultant has approved the sewer or pipeline and has given permission for the trenches to be refilled the pipes become damaged and loses water from any cause and/or admit subsoil water, the Contractor shall uncover the pipes and make good the defect and the pipes retested as before and all at the Contractor's expense.

H. Cleaning, Flushing and Pre-Treatment

1. Prior to start-up and hydraulic testing, the Contractor shall clean the entire installation including all fitments and pipe work and the like after installation and keep them in a new condition. All pumping systems shall be flushed and drained at least once through to get rid of contaminating materials. All pipes shall be rodded to ensure clearance of debris, cleaning and flushing shall be carried out in sections as the installation becomes completed.

2. All strainers shall be inspected and cleaned out or replaced.

3. When the entire systems are reasonably clean, a pre-treatment chemical shall be introduced and circulated for at least 8 hours. Warning signs shall be provided at all outlets during pre-treatment. The pre-treatment chemical shall:

   - Remove oil, grease and foreign residue from the pipe work and fittings.
   - Pre-condition the metal surfaces to resist reaction with water or air.
   - Establish an initial protective film

Copyright © Buro Happold Limited

4. After pre-treatment, the system shall be drained and refilled with fresh water and left until the system is put into operation.
5. Details and procedures of the pre-treatment shall be submitted to the client/consultant for approval.

I. Electrical Tests

1. Electrical tests shall comply with the current edition of IEE regulations and requirements enforced by Local Authorities.
2. Electrical insulation tests earth electrode resistance test and cost amenity test shall apply to bus bars, isolators and other equipment and wiring where applicable.
3. A 500V DC instrument shall be used to check the insulation resistance. The reading shall not be less than 1 mega-ohm in all instances.
4. Function simulation tests shall be performed to ensure that the systems have been installed to the control requirements as described in the Specification therein.

J. Pump Drives

1. The direct coupling of the pump drives shall be dismantled before the pump motor control panel is energized.
2. The Contractor shall demonstrate to the client/consultant of acceptable clearances of the coupling alignment for ensuring satisfactory power transmission.
3. The coupling shall not be re-mated again till the correct motor rotation has been demonstrated with power drawn from the energized pump motor control panel.

K. Pump Operating Test

The Contractor shall ensure to the satisfaction of the client / consultant that the installation or portion thereof which has been set to work complies with all requirements including the following:

1. That the plant and apparatus shall be of robust construction and of capacity for the duty specified.
2. That all valves, switches, controls and the like are properly regulated and capable of proper operation and in the case of valves are capable of being shut-off.
3. That all apparatus shall be silent.
4. That all instruments are correctly calibrated and read accurately.
5. That all services are tested in accordance with the details of the relevant clauses of this Specification.

1.7 TESTING AND COMMISSIONING OF FIRE PUMPS AND ANCILLARIES

1. Testing
   i) Pump shall be tested at the factory to determine the following:
      1. Suction on lift or head and Discharge against the specified head when running at the rated speed under Specified.
      2. Power absorbed by the pump at the pump shaft (BP) under the above specified conditions and
      3. Efficiency of the pump under the above specified conditions.

   ii) Pumps shall be tested at manufacturers works and a test certificate furnished before supply and tested at site after installation as per procedure as per clause 13 of 5120 -1968.

Copyright © Buro Happold Limited

A. COMMISSIONING

i) Commissioning of the Fire Hydrant and Sprinkler Systems shall be done to the Satisfaction of Owner/ Consultant and shall commence only after:
   1. All piping, accessories, pumping sets, fire alarm etc. have been completely installed and tested to the satisfaction of the Owner/Consultant.
   2. Electrical connections have been made and direction of motor rotation checked.
   3. Related work by other agencies has been completed in all respects.
   4. Water supply is available in adequate quantity in the tank.

ii) On completion of all related works given above, start pumping set and develop desired pressure in the system.

iii) By opening one hydrant or test valve in sprinkler system, first the jockey pump shall start automatically at desired drop in pressure and then on further fall of pressure, the main pump(s) shall start. If required, make adjustment and retest. Similarly, the stand-by pump shall also be tested for automatic starting at desired drop of pressure. While main fire pump(s) shall be suitable for manual shut-off, the jockey pump shall start and stop automatically by drop of pressure and buildup of pressure respectively.

B. FIRE PROTECTION SYTEM TESTING

1. The entire works included in this Contract shall be fully tested in stages as the work proceeds and on completion of work as applicable.
2. The Contractor shall provide all necessary labor, instruments, equipment, materials, fuel, power and manufacturer's representatives to carry out such tests as may be necessary to satisfy the client / consultant that the installation meets the requirement and intent of the Specification as well as such tests required by Local Authorities.
3. All tests shall be made in the presence of the client / consultant or his representative or any inspecting authority. At least seven working days notice in writing shall be given to the inspecting parties before performing any test.
4. Three copies of all test results shall be submitted to the client on paper within two weeks after completion of the tests.
5. Tests described hereinafter and including all tests prescribed by the Authority having jurisdiction shall be carried out. Any tests proved unsatisfactory shall be repeated to the satisfaction of the inspecting parties.
6. Contractor shall submit hydraulic calculations, shop drawings along with necessary orifice plate selections for approval.
7. All piping in the system shall be tested to a hydrostatic Pressure as indicated elsewhere in this section.
8. Contractor shall rectify leakages, if any, and replace all defective components and retest the system as per above requirements to the satisfaction of Project Manager / Consultant.
9. At least 10% of all the welded joints including field joints shall be radio- graphically tested.
10. After testing, all pipes shall be flushed with domestic water to remove foreign material.
11. Fire Protection System
    a. Check all hydrant valves by opening and closing any valve found to be open shall be closed.
    b. Check all the piping under hydro test.
    c. Check that all suction and delivery connections are properly made for all pump sets.
    d. Check rotation of each motor after decoupling and correct the same if required.

Copyright © Buro Happold Limited

e. Tests run each pump set.

f. All pump sets shall be run continuously for 8 hours (if required with temporary piping back to the tank).

g. Commissioning and Testing

C. FIRE HYDRANT SYSTEM

i) Pressurize the fire hydrant system by running the jockey pump and after it attains the shutoff pressure of the pump.

ii) Open bypass valve and allow the pressure to drop in the system. Check that the jockey pump cuts-in and cuts-out at the preset pressure. If necessary adjust the pressure switch for the jockey pump. Close by-pass valve.

iii) Open hydrant valve and allow the water to below into the fire water tank in order to avoid wastage of water. The main fire pump shall cut-in at the preset pressure and shall not cutout automatically on reaching the normal line pressure. The main fire pump shall stop only by manual push button. However the jockey pump shall cut-out as soon as the main pump starts

iv) Switch off the main fire pump and test check the diesel engine driven pump in the same manner as the electrically driven pump

v) When the fire pumps have been checked for satisfactory working on automatic controls, open fire hydrant valves simultaneously and allow the hose pipes to discharge water into the fire tank to avoid wastage.

vi) Check each landing valve, male and female couplings and branch pipes, for compatibility with each other. Any fitting which is found to be incompatible and do not fit into the other properly shall be replaced by the Contractor. Each landing valve shall also be checked by opening and closing under pressure.

vii) Check all annunciations by simulating the alarm conditions at site.

D. Sprinkler System

a. Start the sprinkler pump and develop the required pressure in the sprinkler pipes.

b. Open the test valve to test the automatic starting of the pump. If necessary, make necessary adjustments in the setting of pressure switch. The sprinkler water gong alarm shall also operate when the test valve is open. This operation is to be done for each and every section of the sprinkler system and the alarm for each section (via flow switch) shall be checked for operation.

c. After satisfactory operation of the pump the Contractor shall set up mock fire and test the system.

d. Check all annunciations by simulating the alarm conditions at site.

Copyright © Buro Happold Limited

1.8 TESTING AND COMMISSIONING OF WATER SUPPLY SYSTEM

A. Water Supply System testing general

1. The entire works included in this Contract shall be fully tested in stages as the work proceeds and on completion of work as applicable.
2. The Contractor shall provide all necessary labor, instruments, equipment, materials, fuel, power and manufacturer's representatives to carry out such tests as may be necessary to satisfy the client / consultant that the installation meets the requirement and intent of the Specification as well as such tests required by Local Authorities.
3. All tests shall be made in the presence of the client / consultant or his representative or any inspecting authority. At least seven working days notice in writing shall be given to the inspecting parties before performing any test.
4. Three copies of all test results shall be submitted to the client on paper within two weeks after completion of the tests. All test reports shall form a part of commissioning manual.
5. Tests described hereinafter and including all tests prescribed by the Authority having jurisdiction shall be carried out. Any tests proved unsatisfactory shall be repeated to the satisfaction of the inspecting parties.
6. Testing shall be done in accordance with IS: 5329 except as may be modified herein under and manufacturer’s recommendations.
7. Entire system shall be tested for water tightness and smoke tightness during and after completion of the installation. No portion of the system shall remain untested. Contractor must have adequate number of expandable rubber bellow plugs, manometers, smoke testing machines, pipe and fitting work tests.
8. All materials obtained and used on site must have manufacturer’s hydraulic test certificate for each batch of materials used on the site.
9. Before use at site all pipes shall be tested by filling up with water for at least 30 minutes. After filling, pipes shall be struck with a hammer and inspected for blow holes and cracks. All defective pipes shall be rejected and removed from the site within 48 hours. Pipes with minor sweating may be accepted at the discretion of the Project Manager.
10. On completion of the work the entire installation shall be tested by smoke testing machine. The test shall be conducted after the plumbing fixtures are installed and all traps have water seal or by plugging the outlets with bellow plugs. Apply dense smoke keeping the top of stack open and observe for leakages. Rectify or replace defective sections.
11. After the installation is fully complete, it should be tested by flushing the toilets, running at least 20% of all taps simultaneously and ensuring that the entire system is self draining, has no leakages, blockages etc. rectify and replace where required.
12. A test register shall be maintained and all entries shall be signed and dated by the Contractor and the Project Manager or his representative.
13. All pipes in wall chase or meant to be encased or buried shall be hydro tested before the chase in plastered or the pipe encased or buried.
14. While doing concealed bathroom work, it is advised to make the required network on floor by proper measurement of different pipe lengths. To avoid misalignment, guiding marks on pipes and fittings should be referred.
15. If any pump fails in or before testing of commissioning. The same shall be replaced without any extra cost to the client.

B. Water supply System Cleaning & Flushing

1. The entire piping system after satisfactory testing shall be thoroughly cleaned and flushed by purging with clean domestic water until clear flow is obtained from each outlet.
2. If any faucet, valve or outlet is found not flowing full, the cause for the same shall be determined and necessary corrections made.
3. All parts removed during the flushing operation such as strainer screens etc. shall be replaced and the system put into operating condition.

Copyright © Buro Happold Limited

C. Disinfection of Domestic Water lines

1. After flushing of all the Hot and Cold Water service piping, all the fresh water supply pipe work and water tanks shall be disinfected using a chlorine solution.
2. System to be disinfected shall include
   a. Domestic fresh water tanks.
   b. Fire water tanks.
   c. Distribution pipe work
3. All pipe work systems receiving suction from the above mentioned tanks apart from the fire systems.
4. Nipples and valves as required to introduce the disinfectant solution, to vent air and to drain the system shall be provided.
5. Sufficient chemical shall be added to the storage tanks so as to obtain a solution containing 50ppm available chlorine.
6. Distribution systems shall be filled with the disinfecting solution and taps shall be opened successively, working progressively away from the storage tank, and closed when the water discharge smells of chlorine. The storage tank shall finally be topped up with disinfecting solution of the above concentration.
7. Disinfectant solution shall be held in the system for a period of 24 hrs and a test for residual chlorine made. If no residual chlorine is found, the system shall be drained and the disinfection procedure repeated. When positive residual chlorine test is accomplished the system shall be flushed with potable water and put into operation.
8. Before handover of the system, copies of the certification and laboratory report (if required) shall be submitted to the Consultant.
9. Under no circumstances the use of any portion of the fresh water system until it is properly flushed disinfected and certified shall be permitted.
10. During disinfection work the contractor shall take all necessary precautions to prevent site staff from drinking the system water. Such precautions shall include locking doors to ‘Wet’ areas and providing warning signs in English and Hindi.

1.9 TESTING AND COMMISSIONING OF DRAINAGE SYSTEM

A. Carry out all tests and inspections to prove that the installation meets the requirements of the Building Regulations and BS EN 12056-2.

B. Carry out all tests required by the building control officer giving adequate notice. Should the installation fail to hold against any test, identify the location of the failure or leak, rectify and re-test at no additional cost to this contract.

C. Tests shall include all new pipework and fittings from the point of connection to the underground drainage, to the point of connection and termination at roof level as a vent pipe.

D. The installation shall be tested section by section as the work proceeds and subsequently on completion, to ensure that the installation is free from superfluous matter and obstruction and that all work which is to be concealed, is free from defects before it is finally enclosed. Systems shall be submitted to two separate tests, air test and hydraulic performance test in accordance with BS EN 12056-2.

E. The waste and sanitary drainage pipework systems shall be air tested at a pressure equal to 38mm water gauge which shall remain constant for a period of 3 minutes. Pipes shall be tested in the presence of the supervising officer and all pipework shall be visible at the time of the test. All test bungs are to be removed in the presence of the owner’s representative.

F. Before testing, all waste and sanitary drainage pipes shall be cleaned and prepared thoroughly as follows:

Copyright © Buro Happold Limited

- Traps for all appliances and floor gullies shall be plugged and flushed thoroughly with clean water
- Main stacks and branches shall have duct covers and ceiling tiles removed where necessary
- Access covers, cleaning and rodding eyes shall be removed and the stacks rodded by means of drain rods or similar flexible springs and plungers, of a suitable diameter
- Obstructions in pipes shall be removed using suitable cleaning tools
- Care should be taken when carrying out the above operations to ensure deposits and other extraneous matter are not flushed into the drainage system
- In order to be assured of the cleanliness of the system, these cleaning operations shall be carried in the presence of the owner's representative.

G. A water test may be called for, but this shall only apply to the horizontal sections of plumbing and drainage and the section of pipework below the lowest sanitary appliance. This shall be carried out by inserting a plug in the lowest end of the pipe where it enters the inspection chambers and filling the system up to a head of 15m or the flood level of the lowest connected appliance, whichever is the lower.

H. Before commencing air tests all water seals of all sanitary appliances and floor gullies etc. must be fully charged with water and all open ends of pipework i.e. vents and/or outfalls, must be plugged off.

I. All traps must retain not less than 25mm of seal when subjected to the appropriate discharge tests. The number of appliances to be tested shall be as detailed in BS EN 12056-2 Table NG.1.

J. Upon completion of satisfactory testing to all stack pipes, branch pipes and appliances, all duct covers should be re-fixed and ceiling tiles replaced where necessary.

K. Allow for intermediate testing where work is to be concealed by other services. Should final tests reveal defects on concealed pipework, rectify the defects at no additional cost.

L. All tests shall be carried out in the presence of the owner's representative, providing any aid or facilities required. Smoke tests shall not be carried out on plastics pipes.

M. Keep a record of all tests carried out, including the following:
- Date of test
- Location and Identification of the pipeline
- Drawing reference
- Method of test
- Result of test
- Signature of operative undertaking test
- Signature of supervising officer
- Marked up schematic

1.10 TESTING AND COMMISSIONING OF HVAC SYSTEM

A. General

1. Balancing, Testing and Commissioning
Balancing of all air and water systems and all tests as called for the Specifications shall be carried out by the contractor through a specialist group, in accordance with the Specifications and ASHRAE Guide lines and Standards. Performance test shall consist of three days of 10 hour each operation of system for each season. All costs relating to performance witness test of major equipment such as chillers, at factory with two personnel from Owners / Consultant shall be included.

2. The results for summer, monsoon and winter air conditioning in quadruplicate shall be submitted for scrutiny. Four copies of the certified manufacturer's performance curves for

Copyright © Buro Happold Limited

each piece of equipment, high lighting operational parameters for the project, shall be submitted along with the test certificates. Contractor shall also provide four copies of record of all safety and automatic control settings for the entire installation.

3. The installation shall be tested again after removal of defects and shall be commissioned only after approval by the Employer's site representative. All tests shall be carried out in the presence of the representatives of the Employer's site representative.

B. EXAMINATION

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

2. Contract Documents are defined in the relevant sections of specification, drawings and BOQ.

3. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

4. Examine approved submittal data of HVAC systems and equipment.

5. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

6. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

7. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

8. Examine system and equipment test reports.

9. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

10. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

11. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

12. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

Copyright © Buro Happold Limited

13. Examine strainers for clean screens and proper perforations.

14. Examine valves for proper installation for their intended function of diverting or mixing fluid flows.

15. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

16. Examine system pumps to ensure absence of entrained air in the suction piping.

17. Examine equipment for installation and for properly operating safety interlocks and controls.

18. Examine automatic temperature system components to verify the following:

    - Dampers, valves, and other controlled devices are operated by the intended controller.
    - Dampers and valves are in the position indicated by the controller.
    - Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
    - Automatic modulating and shutoff valves, including two-way valves and three way mixing and diverting valves, are properly connected.
    - Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
    - Sensors are located to sense only the intended conditions.
    - Sequence of operation for control modes is according to the Contract Documents.
    - Controller set points are set at indicated values.
    - Interlocked systems are operating.

19. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

C. PREPARATION

1. Prepare a TAB plan that includes strategies and step-by-step procedures.

2. Complete system readiness checks and prepare system readiness reports. Verify the following:

    - Permanent electrical power wiring is complete.
    - Hydronic systems are filled, clean, and free of air.
    - Automatic temperature-control systems are operational.
    - Equipment and duct access doors are securely closed.
    - Balance, smoke, and fire dampers are open.
    - Isolating and balancing valves are open and control valves are operational.
    - Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
    - Windows and doors can be closed so indicated conditions for system operations can be met.

D. GENERAL PROCEDURES FOR TESTING AND BALANCING

1. Perform testing and balancing procedures on each system according to the procedures contained in [AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems"] [NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"] [SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"] and this Section.

Copyright © Buro Happold Limited

2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

3. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fanspeed-control levers, and similar controls and devices, to show final settings.

4. Take and report testing and balancing measurements in [inch-pound (IP) and metric (SI)] units.

E. GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
2. Prepare schematic diagrams of systems' "as-built" duct layouts.
3. For variable-air-volume systems, develop a plan to simulate diversity.
4. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
5. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
6. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
7. Verify that motor starters are equipped with properly sized thermal protection.
8. Check dampers for proper position to achieve desired airflow path.
9. Check for airflow blockages.
10. Check condensate drains for proper connections and functioning.
11. Check for proper sealing of air-handling unit components.
12. Check for proper sealing of air duct system.

F. GENERAL PROCEDURES FOR CHILLED WATER PIPE TESTING

1. 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.

2. All piping shall be tested to hydrostatic test pressure of at least two times the maximum operating pressure, but not less than 10 kg per sq. cm gage for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved.

3. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

4. Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

5. 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 Owner’s site representative.

6. The contractors shall provide temporary pipe connections to initially by-pass chiller and circulate water through chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.

7. The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the Contractor shall rectify the

Copyright © Buro Happold Limited

defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and re-finishing of floors and walls if required.

8. After the piping has been installed, tested and run for at least three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats, 3 mils each of approved color, 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.
9. After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral.
10. Passivation of Water Piping
    a. The M. S. pipe line should be passivated by following method-
    b. Rinse the M. S. pipe line with water 4 times to remove all dust & dirt.
    c. Circulate mild solution (@5%) of Sulphuric acid or oxalic acid for 24 HRS.
    d. Rinse the M. S. pipe line with water to remove the acid content.
    e. Circulate mild solution (@2%) of Caustic soda for 24 HRS and rinse the line with water.
    f. Circulate solution of SODIUM HEXA META PHOSPHATE in ratio of 10 Gm. per Liter for 12-14 hours.
    g. Drain the solution and check the pipe surface. If found O. K. fill the line again and drain again before final charging of fresh soft water.
    h. A required dozing of Anti Oxidant is required to add periodically.
    i. A chemical pot feeder along with necessary piping and accessories to be provided to inject the chemicals in the system.
11. Before commissioning employers site representative shall be provided with certificate of cleaning of pipe systems, signed by the contractor.
12. The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing
13. After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.
14. 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.
15. Complete certified balancing report shall be submitted for evaluation and approval by Owner's site representative. Upon approval, four copies of the balancing report shall be submitted with the as-installed drawings and completion documents.

G. PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

1. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

    - Measure fan static pressures to determine actual static pressure as follows:
        - Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
        - Measure static pressure directly at the fan outlet or through the flexible connection.
        - Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
        - Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling

Copyright © Buro Happold Limited

unit, rooftop unit, and other air-handling and -treating equipment.
- Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

7. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

   i. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
      - Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

   ii. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

8. Measure terminal outlets and inlets without making adjustments.
   i. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

9. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

   i. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   ii. Adjust patterns of adjustable outlets for proper distribution without drafts.

H. PROCEDURES FOR MOTORS

1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   - Manufacturer, model, and serial numbers.
   - Motor horsepower rating.
   - Motor rpm.
   - Efficiency rating.
   - Nameplate and measured voltage, each phase.
   - Nameplate and measured amperage, each phase.
   - Starter thermal-protection-element rating.
2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and

Copyright © Buro Happold Limited

serial numbers, and nameplate data.

I. PROCEDURES FOR CONDENSING UNITS

1. Verify proper rotation of fans.
2. Measure entering- and leaving-air temperatures.
3. Record compressor data.

J. PROCEDURES FOR BOILERS

1. If hydronic, measure entering- and leaving-water temperatures and water flow.
2. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

K. PROCEDURES FOR TEMPERATURE MEASUREMENTS

1. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
2. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
3. Measure outside-air, wet- and dry-bulb temperatures

L. PROCEDURES FOR VIBRATION MEASUREMENTS

1. Use a vibration meter meeting the following criteria:

   i. Solid-state circuitry with a piezoelectric accelerometer.
   ii. Velocity range of 0.1 to 10 inches per second (2.5 to 254 mm/s).
   iii. Displacement range of 1 to 100 mils (0.0254 to 2.54 mm).
   iv. Frequency range of at least 0 to 1000 Hz.
   v. Capable of filtering unwanted frequencies.

2. Calibrate the vibration meter before each day of testing.

   i. Use a calibrator provided with the vibration meter.
   ii. Follow vibration meter and calibrator manufacturer's calibration procedures.

3. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

   i. Turn off equipment in the building that might interfere with testing.
   ii. Clear the space of people.

4. Perform vibration measurements after air and water balancing and equipment testing is complete.

5. Clean equipment surfaces in contact with the vibration transducer.

6. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

7. Measure and record vibration on rotating equipment over 3 hp (2.2 kW).
8. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

   i. Pumps:
      - Pump Bearing: Drive end and opposite end.
      - Motor Bearing: Drive end and opposite end.
      - Pump Base: Top and side.

Copyright © Buro Happold Limited

- Building: Floor.
- Piping: To and from the pump after flexible connections.

ii. Fans and HVAC Equipment with Fans:
- Fan Bearing: Drive end and opposite end.
- Motor Bearing: Drive end and opposite end.
- Equipment Casing: Top and side.
- Equipment Base: Top and side.
- Building: Floor.
- Ductwork: To and from equipment after flexible connections.
- Piping: To and from equipment after flexible connections.

iii. Chillers and HVAC Equipment with Compressors:
- Compressor Bearing: Drive end and opposite end.
- Motor Bearing: Drive end and opposite end.
- Equipment Casing: Top and side.
- Equipment Base: Top and side.
- Building: Floor.
- Piping: To and from equipment after flexible connections.

9. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

10. Inspect, measure, and record vibration isolation.

- Verify that vibration isolation is installed in the required locations.
- Verify that installation is level and plumb.
- Verify that isolators are properly anchored.
- For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
- Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

M. PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

1. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

2. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

3. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 m/s), use a windscreen on the microphone.

4. Perform sound-level testing after air and water balancing and equipment testing are complete.

5. Close windows and doors to the space.

6. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

7. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-ofsight between the sound source and the sound-level meter.

Copyright © Buro Happold Limited

8. Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

9. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

10. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.

    - Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

11. Perform sound testing at three locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.

    - Guest Rooms/Villas.
    - Open office area.
    - Conference rooms/meeting rooms.
    - Ball rooms/function areas.
    - Training room.
    - Hotel suites.
    - Each space with a noise criterion of RC or NC 25 or lower.
    - Each space with an indicated noise criterion of RC or NC 35 and lower that is adjacent to a mechanical equipment room or roof mounted equipment.
    - Inside each mechanical equipment room.

N. PROCEDURES FOR STAIR-WELL PRESSURIZATION SYSTEM MEASUREMENTS AND ADJUSTMENTS

1. Before testing, observe the stair tower to verify that construction is complete. Verify the following:
    - Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
    - Firestopping and sealants are installed.
    - Doors, door closers, and door gaskets are installed and adjusted.
    - If applicable, window installation is complete.

2. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

3. Test each stair tower as a single system. If multiple fans serve a single stair tower, operate the fans together.

4. Air Balance:
    - Open the doors indicated to be open and measure, adjust, and record the airflow of each:
        - Stair-tower fan.
        - Air outlet supplying the stair tower.

    - For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

5. Pressurization Test:

    - After air balancing is complete, perform stair-tower pressurization tests.
    - Establish a consistent procedure for recording data throughout the entire test.

Copyright © Buro Happold Limited

Set the stair-tower side of the doors as the reference point and the floor side of the doors with positive pressure when higher than the stair tower, and negative pressure when lower than the stair tower.

- With the HVAC systems operating in their normal mode of operation and the stair-tower pressurization systems off, measure and record the following:
  - Pressure difference across each stair-tower door with all doors in the stairwell closed.
  - Force necessary to open each door, using a spring-type scale.

- With the HVAC systems operating and the stair-tower pressurization system activated, perform the following:
  - Place building HVAC systems in their normal operating mode including equipment not used to implement smoke control, such as air-handling units, toilet exhaust fans, fan coil units, and similar equipment.
  - Measure and record the pressure difference across each stair-tower door with all doors in the stair tower closed. Adjust the stair-tower pressure relief to prevent overpressurization.
  - Use a spring scale to measure and record the force needed to open the door closest to the fan. With the initial door held in the open position, measure and record the pressure difference across each remaining closed stair-tower door.
  - Open additional doors (up to the number indicated) one at a time, and measure and record the pressure difference across each remaining closed stair-tower door after the opening of each additional door.
  - Open the doors indicated to be open and measure and record the direction and velocity through each of the open doors by a traverse of every 1 sq. ft. (0.093-sq. m) grid of door opening.
  - Calculate the average of the door velocity measurements. Compare the average velocity to the Contract Documents and governing code requirements.
- Repeat the pressurization tests with the smoke-control systems and the HVAC systems operating.
- Criteria for Acceptance:
  - The opening force on any door shall not exceed 30 lbf (133 N).
  - Code requirements.

6. Operational Tests:
   - Check the proper activation of the stair-tower pressurization system(s) in response to all means of activation, both automatic and manual.
   - Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
     - Normal.
     - Alarm.
     - Manual override of normal mode and alarm.
     - Return to normal.
   - Verify that the smoke detector at the stair pressurization fan inlet de-energizes the fan and closes the damper at the fan.

   - If standby power is provided for stair pressurization systems, test to verify that the stair pressurization systems operate while on both normal and standby power.
   - Conduct additional tests required by authorities having jurisdiction.

7. Prepare a complete report of observations, measurements, and deficiencies.

Copyright © Buro Happold Limited

1.11 STATUTORY AUTHORITIES TESTS AND INSPECTIONS

A. As and when notified in writing or instructed by the client/ consultant, the contractor shall submit shop drawing and attend all tests and inspections carried out by Local Authorities and other Statutory Authorities shall forthwith execute free of charge any rectification work ordered by the client/ consultant as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

B. The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

C. The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the client/consultant for checking before submission. The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within six months after the award of the Contract but not less than six weeks before the inspection. The client/consultant may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

D. The Contractor shall notify the client/consultant at least seven days in advance of his application for local Authority tests and inspections. On receipt of a confirmed date for test and inspection the Contractor shall inform the client/consultant without delay.

1.12 PRELIMINARY COMMISSIONING CHECKS

A. Ensure that all equipment & system is thoroughly cleaned, lubricated and checked for serviceability before setting to work. Particular attention is drawn to the removal of building debris from the pipe work systems.

B. Special attention is drawn to the need for thoroughly flushing out all pipe work systems to ensure that all foreign matter is removed.

C. All automatic controls and safety devices shall be inspected and checked for service ability before the working fluid or electricity is applied to the system.

1.13 COMMISSIONING

A. When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all system in the entire installation. Special attention shall be paid to the following items:

1. That all valves, switches, controls, etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.
2. That all apparatus is silent in accordance with the requirements of this Specification.
3. That all instruments are correctly calibrated and read accurately.
4. That all services are tested in accordance with the details in the relevant clauses of this Specification.
5. Operate pumps, pressure reducing sets, etc. to ensure that all control systems are functioning correctly and are properly set, sequenced or interlocked.

1.14 FINAL ACCEPTANCE TESTS

A. Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final acceptance tests in accordance with a programme to be agreed with the client/consultant.

Copyright © Buro Happold Limited

B. Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance is obtained.

C. Where acceptance tests are required by the relevant Authorities having jurisdiction, these tests shall be carried out by the Contractor prior to the issue of Completion Certificate to the acceptance of the Authorities.

D. Final approval of commissioning of the equipment is subjected to clearance of LEED commissioning consultant and the Chief Fire officer, Mumbai.

1.15 REJECTION OF PLANT

A. Any item of plant or system or component which fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected by the client/consultant either in whole or in part as he considers necessary/appropriate. Adjustment and/or modification work as required by the client/consultant so as to comply with the Authority's requirements and the intent of the Specification shall be carried out by the Contractor at his own expense and to the satisfaction of the Authority/client/consultant.

B. After works have been accepted, the Contractor may be required to carry out assist in carrying out additional performance tests as reasonably required by the Employer.

1.16 HANDING OVER OF DOCUMENTS

A. All testing and commissioning shall be done by the Contractor to the entire satisfaction of the Client and all testing and commissioning documents shall be handed over to the Client.

B. The Contractor shall also hand over all maintenance and operation manuals, all certificates and all other documentation as per the terms of the contract to the Client.

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

LODHA CLARIANT

TENDER SPECIFICATION

FOR

PLOT C SALES GALLERY

BH-ZSG-SPE-M-0001

INTERNAL HVAC SERVICES

00	Nov 2015	Tender	TA	KJ	LODHA
Rev	Date	Issue	Prepared by	Checked by	Client

INDEX- PLOT C SALES GALLERY

VOLUME	SECTION	DESCRIPTION
VOLUME 01	A	GENERAL
VOULME 02	B	TECHNICAL SPECIFICATION – HVAC SYSTEM
	C & D	EQUIPMENT SCHEDULE
	E	SCHEDULE OF DEVIATIONS FROM TECHNICAL SPECIFICATION
	F	SCHEDULE OF DEVIATIONS FROM GENERAL & SPECIAL CONDITIONS OF CONTRACT, BOQ/SCHEDULE OF PRICES
	G	LIST OF APPROVED MAKES
VOLUME 03	H	PREAMBLE TO BILL OF QUANTITY/SCHDULE OF PRICES
	I	BILL OF QUANTITY (BOQ)
	J	LIST OF DRAWINGS
	K	SCOPE OF DRAWINGS

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – A

GENERAL CONDITIONS OF CONTRACT

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

1.1 SUMMARY

A. This Section includes technical specifications for Lodha Kolshet Plot C Sales Gallery Internal HVAC System.

B. The entire work shall be carried out in a manner consistent with good engineering practice. The Contractor shall take into account all site conditions including space allocation for HVAC System while designing the system and selecting the equipment.

C. The Contractor shall be responsible for engaging a qualified, competent and experienced HVAC System specialist to perform the system design verification, preparation and submission of system proposal, obtaining approvals from relevant authorities and site supervision for installation, testing and commissioning.

D. The Contractor shall perform the system design verification based on the criteria / data and technical requirements specified in this section / drawings and the local Authorities regulations / requirements.

E. The Contractor shall provide system which comprises products of manufacturers who have designed, developed and used these products successfully for a period of at least for last five years.

F. The Contractor shall submit catalogue information, design calculations and samples complete with full technical data and shop drawings for the entire system, test certificates, etc. and any other information required by client consultant for acceptance prior to commencement of installation.

G. The contractor shall provide the Air Conditioning system which can be interfaced with Home automation system.

1.3 CO-ORDINATION

A. Work shall be carried out in conformity with the specifications and accompanying drawings after approval by the Interior Designer/Consultant. The Contractor shall be responsible for taking actual measurements at site and varying the work in detail if required to meet the site conditions. Such deviations shall, however, be subject to the approval of the Employers Representative's.

B. The Contractor shall also co-operate with the Employers Representative's other Contractors, compare and coordinate drawings, specifications and time schedules and so arrange his work that there will be no interferences .The Contractor shall forward to the Employers Representative's copies of all correspondence and drawings so exchanged. Failure to check plans and conditions will render the Contractor responsible for bearing the cost of any subsequent change found necessary.

C. HVAC contractor is responsible for providing input in preparation of co-ordinated services layout for each apartment.

D. The contractor shall be required to do the part / complete installation work in phases so as to take maximum advantage of the work front as and when it gets available.

1.4 SYSTEM PERFORMANCE GUARANTEE

A. The contractor shall carry out the work in accordance with the Approved shop drawings, Specifications, Schedule of Quantities and other documents forming part of the Contract.

B. The contractor shall be fully responsible for the performance of the selected equipment (installed by him) at the specified parameters and for the efficiency of the installation to deliver the required end result.

C. The contractor shall guarantee that the HVAC system as installed shall maintain the inside conditions in the air-conditioned spaces as described under "Basis of Design" in the specifications

Copyright © Buro Happold Limited

D. The contractor shall also guarantee that the performance of various equipments individually, shall not be less than the quoted capacity; also actual power consumption shall not exceed the quoted rating, during testing and commissioning, handing over and guarantee period.

E. The contractor shall verify the AC load computed by consultant. For this, the contractor shall obtain the latest design basis from the Owner (i.e. lighting load, equipment load, latest architectural & interior plans and occupancy) to cross-check and calculate the capacity of various equipments.

1.5 SYSTEM UPTIME GUARANTEE

A. The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defects liability period, the Defects Liability period shall get extended by a month for every month having shortfall. In case of shortfall beyond the defects liability period, the contract for Operation and Maintenance shall get extended by a month for every month having the shortfall and no reimbursement shall be made for the extended period.

B. The Contractor shall provide log in the form of CD and bound printed comprehensive log book containing tables for daily record of all temperatures, pressures, humidity, and power consumption. Starting and stopping times for various equipments, daily services rendered for the system alarms, maintenance and record of unusual observations etc. Contractor shall also submit preventive maintenance schedule.

C. Each tenderer shall submit along with the tender, a detailed operation assistance proposal for the Owner's site representatives/Consultant's review. This shall include the type of service planned to be offered during Defects Liability Period and beyond. The operation assistance proposal shall give the details of the proposed monthly reports to the Management.

D. The tenderer shall include a list of other projects where such an Operation Assistance has been provided.

1.6 ELECTRIC SUPPLY

A. Three phase electric supply will be 415 V. 50 Hz, 4 wires.

B. Single phase electric supply will be 240 V, 50 Hz, 3 wires.

1.7 INSTRUCTION TO TENDERER/ BIDDER

A. The Bidder / Tenderer shall furnish all the information called for in the all the sections of this contract, failing which the bid will be treated as incomplete and the Employers Representative's reserves the right to reject the bid. The Tenderer is advised to fill information strictly in the format enclosed.

B. The Bidder shall carefully study all sections and drawings enclosed (if any) with specification and indicate deviations in the relevant Sections of the Specification. If no deviations are stated it will be assumed that the offer conforms in all respects to the specification and the Employers Representative's reserves the right to evaluate the Bid as such without further reference to the Bidder.

C. The Bidder is also advised to have discussion with Employers Representative's before preparing the Bid and bring out clearly in the Bid any discrepancies found in the tender package or any items which in his opinion have not been included in the tender package but is required for the completion of the project.

D. The Bidder must obtain for himself on his own responsibility and at his own expense all the information's which may be necessary for the purpose of making a tender and for entering it into a contract and must examine the drawings, inspect the site of the work and acquaint himself with all local conditions means of access to the work, nature of the work and all matters appertaining thereto.

E. Time allowed for carrying out the work as mentioned in the Memorandum shall be strictly observed by the Contractor and it shall be reckoned from the day written order to commence the work is issued. The work shall throughout the stipulated period of the contract be proceeded with all due diligence and if the contractor fails to complete the work within the

Copyright © Buro Happold Limited

specified period he shall be liable to pay compensation as defined in the General Conditions of Contract. The Bidder shall before commencing work prepare a detailed work programme which shall be approved by the consultants and the Employers Representative's.

F. Each Bidder shall submit in his bid a list of large works of a like nature he has executed giving details as to their magnitude and cost, the proportion of work done by the Contractor in it and the time within which the works were completed, the Bidder shall also submit along with his bid a list mentioning the names of manufacturers of specialised items.

G. The successful Bidder is bound to carry out any item of work necessary for the completion of the job even though such items are not included in the quantities and rates. Schedule of instructions in respect of such additional items and their quantities will be issued in writing by the Consultants with the prior consent in writing to the Employers Representative's.

1.8 QUALITY ASSURANCE AND QUALITY CONTROL

A. The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. Quality standards prescribed shall form the backbone for the quality assurance and quality control system.

B. Following plans shall be prepared and submitted to Employers Representative's within 30 days after award of the contract

   a. Quality Plan to be submitted for approval.

   b. QA/QC Procedure and Inspection Test Plan.

   c. Material inspection report. (all incoming material)

   d. Work Inspection Report (Installation inspection)

   e. Area Clearance and handing over formats.

   f. QA/QC team structure.

C. At the site level the Contractor shall arrange the materials, their stacking/ storage in appropriate manner to ensure the quality. Contractor shall provide equipment and manpower to test continuously the quality of materials, assemblies etc. as directed by the Engineer. The test shall be conducted continuously and the result of tests maintained. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of surface.

D. The Consultant shall be free to carry out tests as may be considered necessary by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

E. The test shall be conducted at the site laboratory that may be established by Consultant or at any other Standard Laboratory selected by Consultant.

F. The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of Contractor failing to arrange transportation of the samples in proper time Consultant shall have them transported and recover two times the actual cost from the Contractor's bills.

1.9 EXTENT OF SERVICE

A. Works to be carried out under this Contract is the design verification, shop drawing, selection, manufacture, supply, installation, testing and commissioning of the Apartment HVAC System and associated installation to comply with the requirements from any authorities having jurisdiction over the said system and installation and the requirements on performance, materials and equipment as stipulated in the Technical Specifications.

B. Contractor's attention is drawn specially to the space / area limitation shown on the drawings for compliance.

C. Contractor shall also note the limitation of equipment access as shown on the drawings and shall ensure that all equipment can be safely transferred to the planned space. Contractor

Copyright © Buro Happold Limited

shall include in scope if necessary the work for dismantling and reassembly / assembly of the equipment to accommodate any access restriction.

D. Clearing away rubbish.

E. Tools, Tackles, Scaffolding including the provision, maintenance and removal of any special scaffolding as required.

F. Unloading, distribution and placing in position all plant, machinery, etc.

G. Coordination of the other services entering in your work front.

H. Cutting chases for pipes and the like in walls, floors, partitions etc (except on structural members) and the like and subsequent making good.

I. Cutting or forming holes for pipes, ducts and the like through walls, floors, partitions, roofs and the like (except Structural members), subsequent making good and providing sleeves and/or sub-frames as required.

J. Pinning ends of supports for pipes, equipment, appliances, fittings and the like to wall, floors, partitions, soffits etc and making good.

K. Leaving mortices, sinking and the like for holding down bolts, brackets, supports and the like and grouting in.

L. Filling around, boring holes through and making good of finishing up to pipes, supports, brackets and the like.

M. Building of the meter pits, access chambers and sump pits and parking drains.

N. Application of Paint on exposed pipe work, fittings, equipment and the similar items with Rust proof paint.

O. Concrete equipment bases, pipe supports, plinths, suspended slabs, steel support beams and the like, together with all necessary waterproofing, sound attenuation, and the like as required.

P. All Structural (Metallic / Non-metallic) requirements for the installation of the System to be complete and will be in the scope of the contractor.

Q. The contractor must bear in mind that all the work shall be carried out strictly in accordance with the approved specifications and approved working drawings as instructed by the Employers Representative's and also in compliance with the local public authorities and to the requirements of any acts, rules and regulations. No deviation on any account will be permitted.

R. Any other Minor civil work pertaining to main work

S. Getting all approvals as required from Statutory / Local authorities required during construction and till commissioning and handing over the entire fire fighting system.

T. Electrical works from and including control panel, inside the HVAC system plant room.

1.10 WORKS BY OTHERS

Following works will be excluded from this Contract and shall be carried out by other Agencies:

A. All Major civil works such as R.C.C. tanks, opening on structures.
B. Electrical supply to work front. The Employer does not guarantee continuous supply of Power and no compensation whatsoever shall be allowed for supply becoming intermittent or for break downs in contractors Equipment's.
C. Ventilation and general lighting for the plant room during construction.
D. False ceiling work as shown on the Interior Designer's/Consultant's drawings.
E. Electricity and water as required for the erection, testing and commissioning free of charges.
F. Electrical Supply will be provided till the control panel inside the plant room.

1.11 DRAWINGS AND LITERATURE

A. List of Equipment/ Materials:

Copyright © Buro Happold Limited

B. The Following submittals shall be included with the tenders. Failure to provide the required information may cause rejection of the tender. Detailed equipment list, identifying types, models, and all materials & equipment proposed. This submittal shall include manufacturer's data sheets showing the types and models of all equipment and materials. The submittals shall be in the format given in relevant sections of tender documents.

C. When a data sheet shows more than one make, the proposed make shall be clearly indicated by arrows or other suitable means.

D. The data shall be submitted in a ring binder, indexed by product.

E. The data shall not include superfluous cut sheets (i.e., unedited manufacturer's catalogues are not acceptable).

F. Shop Drawings / Technical Data:
   1. After the award of work, the Contractor shall submit shop drawings including Builders Work Drawings and technical data for approval. Shop drawings and technical submittals shall include sufficient data to indicate complete compliance with Specification, Contract Documents and System Requirements. Submissions shall be in the form of drawings, brochures, catalogues and/or narrative descriptions with certified standards.
   2. The tender drawings represent the design intent and a feasible scheme / layout that may be re-arranged in the space allocated during the shop drawing preparation subjected to prior approval by the Architect/ Consultant before the actual shop drawing and execution.
   3. After the award of work, all changes in architectural, structural, interior design, facilities planning or any decision of Employers Representative's / Architect / Consultant causes redesign of the system, the contractor shall carry out the same in shop drawings and calculations and get approval from the Consultant. Consultants will advise / guide the Contractor to carry out such changes but will not provide any drawing further to the tender drawings, issued with these documents.
   4. Approval by the Employers Representative's/ Architect/ Consultant of the Technical Submittals and drawings shall not relieve the contractor of any part of his obligation to meet all the requirements of the Contract or of the correctness of his drawings. The Contractor shall be responsible for and pay for all alterations of the works due to discrepancies or omissions in the drawings or other particulars supplied by him, whether such drawings have been approved by the Employers Representative's/ Architect/ Consultant or not.

G. As-Built Drawings:
   1. A separate set of approved shop drawings corrected to indicate the as-built conditions shall be kept at the site. These drawings shall be maintained in a current condition at all times and shall be made available for review upon request. All variations from the approved shop drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials and/or required coordination between other Contractors shall be indicated in sufficient detail to accurately reflect the as-built conditions.
   2. Upon completion of the work, before final payment, one complete Master set and two additional blue-line sets of As-built drawings shall be submitted for approval, which shall include plans, sections, specific details, schematic diagrams, riser diagrams, control diagrams and any other drawing as directed by the Employers Representative's.
   3. Contractor shall submit As-built drawings on DVD in addition to the above. All drawings shall be made on Auto CAD.

H. Quality Control Submittals:
   1. Proof of compliance to applicable codes and standards.
   2. Final commissioning and testing reports.

I. Operation and Maintenance (O & M) Manuals : Shall be as described in scope o work document.

J. Operation and Maintenance (O & M) Manuals :
   1. Submit two (2) draft copies of O & M manuals for review. After review by Employers Representative's representative, the Contractor shall incorporate review comments and submit Six (6) final copies.

Copyright © Buro Happold Limited

2. During guarantee period, the Contractor shall update the manuals with modifications made to system, providing replacement pages or supplements in quantity stated above.
3. O & M manuals shall be assembled into multi-volume sets as necessary and required by the Employers Representative's.
4. Each volume shall be protected with a heavy duty vinyl plastic binder. Volumes shall have plastic printed dividers between major sections and shall have oversized binders to accommodate up to 20 mm thick set of additional information.
5. Each binder shall be silk screened with project name and volume title on front cover and binder.
6. First page of each manual shall be identified with project name, manual title, Employers Representative's name, Consultant's name, address and service phone number and person who prepared the manual.
7. Operating and maintenance Manual shall serve as training and reference manual for all aspects of day-to-day operation of the system, such as:
   - Step by step direction.
   - Provision of alarms and their sequences.
   - Do's and Don'ts in operation.
   - Fault location and remedy chart.
   - Schedule of spares.

1.12 TESTING:

A. All equipment and the whole system shall be tested as required by the various sections of the specifications and test data as required shall be furnished.

B. Routine tests for the various items of equipment shall be performed at the Contractor's works and relevant test certificates to be furnished. If required by the Employers Representative's, have the Contractor shall permit the Employers Representative's authorised representative to be present during any of the tests. After notification of the Employers Representative's that installation has been virtually completed, the Contractor shall conduct under the direction and in the presence of the Employers Representative's, such tests and inspection as been specified or as the Employers Representative's shall consider necessary to determine whether or not the full intent of the Requirements of the drawings and specifications have been fulfilled. In case the work does not meet the full intent of the specifications and further tests considered necessary, the Contractor shall conduct such tests and bear the expenses thereof.

C. Contractor shall operate, test and adjust all systems equipment, pumps, motors, Control equipment, other electrical equipment provided in connection with this installation and shall make all necessary adjustments and corrections to establish the specified system / equipment capacity at given designed condition.

D. All equipment and systems shall be tested after installation and test readings submitted as specified.

1.13 REJECTION OF DEFECTIVE EQUIPMENT

A. If the completed system installation or any portion thereof, before it is taken over or during the guarantee and defects liability period, be found defective or fails to fulfil the intent of these specifications, the Contractor shall on receipt of notice from the Employers Representative's forth with dismantle and replace the defective equipment/ material/ system installations.

B. Should he fail to do so within 15 days of intimation by the Employers Representative's, the Employers Representative's may reject and replace at the risk and expense of the Contractor the whole or any portion of the equipment/ material/ system installations found defective or fails to fulfil the requirements of the Contract.

C. The Employers Representative's shall have the right to operate all equipment/ System/ Installation in operating condition whether or not such equipment/ system/ installation have been accepted as complete and satisfactory. Repairs and alterations shall be made at such times and as directed by the Employers Representative's.

1.14 SAFETY CODE

Copyright © Buro Happold Limited

A. There shall be maintained in a readily accessible place first-aid appliances including adequate supply of sterilized dressing and cotton wool.

B. The injured person shall be taken to a public hospital without loss of time.

C. Suitable and strong scaffolds should be provided for workmen for all works that cannot be done safely from the ground.

D. No portable single ladder shall be over 8 metres in length. The width between the side rails shall not be less than 30 cm (clear) and the distance between the two adjacent rungs shall not be more than 30 cm. When a ladder is used an extra mazdoor (labour) shall be engaged for holding the ladder.

E. Every opening in a floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing whose minimum height shall be one metre.

F. No floor, roof or other part of the structure shall be as over-loaded with debris or materials as to render it unsafe. Workers employed on mixing and handling material such as asphalt, cement mortar, concrete or lime mortar shall be provided with protective footwear and hand-gloves.

G. Protective gear such as safety helmets, boots, belts, etc. shall be provided by the Contractor at his own cost to all his manpower at site. The Contractor shall impose such requirements on all Sub-Contractors also. It shall be the responsibility of the Contractor to ensure that such protective gear is worn at all times by all personnel working at site. The Project Manager/ Engineer shall have the right to stop any person not wearing such protective gear from working on the site.

H. Those engaged in welding works shall be provided with welder's protective eye-shields and gloves. Fire extinguishers must be provided during welding at all times.

I. No paint containing lead or lead products shall be used except in the form of paste or readymade paint.

J. Suitable facemasks should be supplied for use by the workers when the paint is applied in the form of spray or surface having lead paint dry rubbed and scrapped.

K. Overalls shall be supplied by the Contractor to the painters and adequate facilities shall be provided to enable the working painters to wash during the cessation of work.

L. In case the Contractor fails to make arrangements and provide necessary facilities as aforesaid, the Employers Representative's shall be entitled to do so and recover the costs thereof from the Contractor. The decision of the Employers Representative's in this regard shall be final and binding on the Contractor.

M. Use of hoisting machines and tackle including their attachments, anchorage and supports shall be in perfect condition.

N. The ropes used in hoisting or lowering material or as a means of suspension shall be durable and in perfect condition.

O. All electrical connections for construction activity shall be taken through proper receptacles only. No loose wire connections shall be allowed.

1.15 CONTRACTOR'S REPRESENTATIVES

A. The Contractor shall employ qualified representatives on full time basis (and shall be available at site) whose name shall have previously been communicated in writing to the Employers Representative's and approved by them to supervise the execution. Any written order or instruction given to the representative shall be deemed to have been given to the Contractor.

B. The Employers Representative's shall be at liberty to object to any particular representative or any persons employed by the Contractor on the work and the Contractor shall remove the person objected to, on receipt from the Employers Representative's, in writing, a request requiring him to do so. The Contractor shall provide in his place another competent representative acceptable to the Consultants.

Copyright © Buro Happold Limited

1.16 CONTRACTOR AGREEMENT - Contractor shall be responsible to read and agree the scope of work as detailed in SOW, GCC & PCC documents.

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – B

TECHNICAL SPECIFICATIONS

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

PART 1 - GENERAL

1.1 HVAC SYSTEM DESCRIPTION

The mechanical systems for the sales gallery consists primarily of air conditioning system using Variable refrigerant Volume outdoor units with Ductable split / Hi-wall Split units as indoor units.

Toilets & Kitchens in the residential units would have exhaust fan.

1.2 BASIS OF DESIGN:

A. Standards

- AHRI 1230 : 2010 Performance rating of Variable refrigerant flow (VRF) multi split air conditioning and heat pump equipment.
- AHRI 365:2009 Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units
- AHRI 210/240:2008 Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
- AHRI 340/360:2007 Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment
- IS 11327:2007 Requirements for refrigerants condensing units
- IS 277:2003 Specification for galvanized steel sheets
- IS 655:2006 Air duct specification
- IS 5111:1993 /ISO 917:1989 Testing of refrigerant compressors
- IS 8148:2003 Packaged air conditioners (first revision)
- IS 660 Safety code for mechanical refrigeration
- IS 817 : 2005 Refrigerant designation system
- IS 1391 Part 2 Room air conditioners specification Part 2 Split air conditioners
- IS 7613:1975 Method of testing panel type air filters for air conditioning and ventilation purposes.
- ANSI/ASHRAE Standard 62.1–2010 “Ventilation for Acceptable Indoor Air Quality”
- ANSI/ASHRAE Standard 55–2010 “Thermal Environmental Conditions for Human Occupancy”
- ANSI/ASHRAE Standard 90.1–2010 “Energy Standard for Buildings Except Low-Rise Residential Buildings”
- ANSI/ASHRAE Standard 34–2010 “Designation and Safety Classification of Refrigerants”
- ANSI/ASHRAE Standard 15-2010 “Safety Standard for Refrigeration Systems
- Electrical motors, cables, wiring and accessories as per ECBC 2009.

Copyright © Buro Happold Limited

B. Guidelines

- Energy Conservation Building Code (ECBC 2009)
- Bureau of Energy Efficiency System Requirements (BEE)
- ISHRAE – Indian Society Of Heating Refrigeration And Air Conditioning Engineers
- ASHRAE Guideline 0–2005 “The Commissioning Process”
- ASHRAE Guideline 1.1-2007 “HVAC and Technical Requirements for The Commissioning Process”
- ASHRAE Guideline 5–1994 “Commissioning Smoke Management Systems”
- ASHRAE Guideline 12-2000 “Minimizing the Risk of Legionellosis Associated with Building Water Systems”
- ASHRAE Guideline 13-2007 “Specifying Direct Digital Control Systems”
- ASHRAE Guideline 14-2002 “Measurement of Energy and Demand Savings”
- ASHRAE Guideline 16-2010 “Selecting Outdoor, Return and Relief Dampers for Air-Side Economizer Systems”
- SMACNA – Installation standards for HVAC systems
- Chartered Institute of Building Services Engineers (CIBSE) guidance
- AHRI – Air Conditioning, Heating & Refrigeration Institute
- AMCA – Air Movement Contractors Association
- ASME – American Society of Mechanical Engineers
- ASTM – American Society for Testing and Materials Ambient Conditions.

Copyright © Buro Happold Limited

C. Geographic Location

1. Site location.: Mumbai
2. Geographic bearing : 19.12 Deg 30'N
3. Altitude : 14 Meters above mean sea level

D. Outdoor Design Conditions

The outdoor design conditions have been considered as follows.

Cooling DB/MCWB @ 0.4 %	**35.9 deg C DB**	**22.7 deg C WB**
Cooling WB/MCDB @ 0.4 %	**31.2 deg C DB**	**27.7 deg C WB**
Heating DB/MCWB @ 99.6%	**16.5 deg C DB**	**13.9 deg C WB**

E. Design Parameters

Centrifugal/ Axial Fans

Maximum fan outlet velocity for Fans up to 450 mm dia.	9 m/s
Maximum fan outlet velocity for Fans above 450 mm dia.	10 m/s
Maximum fan speed for fans up to 450 mm dia.	1450 RPM
Maximum fan speed for fans above 450 mm dia.	1000 RPM.

Cabinet type Centrifugal backward fans

Maximum face velocity across MERV 4 filters	2.5 m/s
Maximum fan outlet velocity :	9 m/s
Maximum fan speed :	
a. Fan above 300 mm dia :	900 RPM
b. Fans upto and including 300 mm dia :	1440 RPM
Maximum fan motor speed :	1450 RPM

END OF PART 1

Copyright © Buro Happold Limited

PART-2 EQUIPMENT AND PRODUCT SPECIFICATION

2.1 EQUIPMENTS

A. Variable Refrigerant Flow (VRF) / Variable Refrigerant Volume (VRV) System

1. Scope:

   Scope of this section comprises the supply, installation, testing and commissioning of VRF/VRV. system as follows :

   a. Indoor units with mounting brackets/supports.
   b. Air-cooled condensing units with outdoor support structure. Outdoor support structure shall be painted with 2 coats of epoxy primer and 2 coats of epoxy paint.
   c. All indoor unit shall have anticorrosive coating and outdoor unit shall have blygold coating.
   d. Fan motor, evaporator motor interlock local isolators for motors.
   e. Hard copper refrigerant piping between outdoor and indoor units as specified elsewhere.
   f. Electrical panels with starters etc., for compressors motors, condenser fan motor and evaporator fan motors.
   g. Digital thermostats and safety controls.
   h. Single phase preventors.
   i. Installation accessories, mounting brackets, filters, drier etc.
   j. First charge of refrigerant gas and oil.
   k. Ducting with insulation and air terminal devices as specified elsewhere.
   l. Drain piping for evaporator units.
   m. Insulation of indoor unit, refrigerant piping and drain piping.
   n. Electrical wiring from isolator power supply provided by others, within 3 Meters away from the outdoor units.
   o. Testing and commissioning.
   p. For detail specification of indoor and outdoor unit refer to point no. G and H
   q. The Contractor shall carry out CFD analysis for the complete proposed installation and equipment shall be ordered based on the results of the analysis.
   r. Selected out door units shall have sufficient static to discharge the hot air against the wind resistance.
   s. All indoor units shall have flexibility for LHS/RHS coil connections. The Contractor to confirm the coil connections with employer's representative before ordering the equipment.

   The Bidder shall submit the technical data sheets as published by manufacturer along with the tender.

2. Materials and Construction:

   The system selected shall be a modular with multiple compressors in each module, with number of indoor units connected to centrally located outdoor units. Outdoor units for all the systems shall be air cooled type and mounted externally..

   a. VRF/VRV air conditioners shall be factory assembled, wired, internally piped & tested. Outdoor units shall be pre-charged with R 410A refrigerant. Additional charge shall be provided as per refrigerant piping at site. All the units shall be suitable for operation with 415 V + 6%, 50 Hz + 3%, 3 Phase supply for outdoor units and 240 V + 6%, 50 Hz + 3%, 1 Phase supply for indoor units.

   b. VRF/VRV system shall provide stable, trouble free, safe operation, with the flexibility of operating desired indoor units. Outdoor units shall be capable of delivering exact capacity proportional to the number of indoor units switched on and the heat load in the air conditioned area. The proportional operation shall be achieved by varying

Copyright © Buro Happold Limited

speed of the compressor in the outdoor units (variable frequency drives). Electronic expansion valves shall be provided in the system.

c. All compressors of the outdoor units shall be hermetically sealed scroll type. Each module of outdoor unit shall have separate scroll compressor with necessary control, suitable to operate at heat load proportional to indoor requirement
d. Selected outdoor unit condenser fans shall have a 6mm external static pressure to discharge the hot air out and overcome the wind pressure at higher elevations
e. Coils of outdoor unit shall have blygold or equivalent corrosion resistance coating
f. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention
g. Outdoor units shall employ system of equal run time for all the compressors, within each outdoor unit – Single Module or Multi Module.
h. Outdoor units shall be suitable to operate within an ambient temperature range of – 5 Deg C to 50 Deg C in cooling mode
i. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up **to 8mm or above of w. g to overcome the wind pressure.** Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity the system.
j. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.
k. Inverter compressor of the unit shall start first & at the minimum frequency, to reduce the inrush current during starting
l. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.
m. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 1.5metre from the unit.
n. Outdoor units shall conform to Technological Guideline for Harmonic Suppression – JAEG 9702 1995. High Harmonic Environmental Target Level for Power Distribution system shall be 5%.
o. The system shall be suitable for delivering the design capacity without deration, up to the following distances.

i) Distance between outdoor and furthest indoor unit - 150 mts.
ii) Vertical distance - 50 mts.
iii) Horizontal distance - 130 mts.
iv) Total refrigerant piping in each system - min 500 mts.

p. Operation of the VRV/VRF system shall be through independent wired/ wireless remote controllers.
q. All units shall be supplied with the following from the factory:

v) Connection pipes & accessories.
vi) Clamps
vii) Installation manual
viii) Operation manual
ix) VRV/VRF controller
x) Communication modules for the home automation units.

3. General Features

Following features shall be provided for all VRV/VRF systems.

ON / OFF Control	ON / OFF control for each individual indoor unit.

Copyright © Buro Happold Limited

Central Control	Central or local control shall be individually selected. In built duty cycling shall be provided.
Mode Selection	Simulated COOL/HEAT operation.
Temperature Setting	Temperature selection from `0' Deg.– 30 Deg.C in cooling mode.
Fan Speed Setting	HIGH-MEDIUM-LOW-OFF
Timer	Multiple daily time ON/OFF settings where temperature, fan speeds can be selected.
Remote Controller Group	Indoor units with remote controller.
Group Setting	Multiple indoor units shall be group set with the same settings by inputting the information on one of the units in the group.
Auto Configuration	All indoor units connected to the network shall automatically be identified and registered.
Fault Status	If a fault occurs, the screen shall display the fault details within 3 minutes and a fault log shall be created. Facility to print the log automatically shall be provided.
System Status	Actual operating conditions for each indoor and outdoor unit shall be monitored on the system display graphics.
Password	A password to prevent unauthorized access to the program.
Search	Where many indoor units are controlled by NETWORK, a search function shall be available to find specific unit locations
Languages	ENGLISH
Help Files	Help files shall be provided in the respective languages.
Error Log	All faults reports shall be stored with date and time information providing a historical record.
Unit Registration	Information concerning the unit models, serial numbers shall be entered for each unit making after sales service easier.
Energy Consumption	Shall allow the demand of individual units to be calculated as a percentage of total system energy consumption over selected time periods.
Historical Information	Operation conditions shall be recorded at selected time intervals for help with monitoring and trouble shooting.
Filter Maintenance	An indication shall appear, at selected time intervals, when it is necessary to inspect the filter.

Copyright © Buro Happold Limited

4. Testing:

a. Unit capacity in Tons Refrigeration shall be computed from the temperature readings.

b. All instruments, services needed for the tests required for the computation of capacities and power consumption shall be provided by the Contractor. All instruments shall be calibrated and the Contractor shall produce calibration certificates in support.

5. Painting:

All equipment including mounting frames, etc., shall be painted with two coats of a suitable paint of approved color. All steel members/parts shall be given an undercoat of zinc chromate before the application of 2 coats of paint

B. INDOOR UNITS FOR APARTMENTS

1. Scope :

a. Scope of this section comprises the supply, installation, testing and commissioning of indoor units for VRV A.C. System.

2. General Requirements :

a. All units shall be supplied with the following from the factory:
   i) Drain hose/ clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting inclusive of anti-vibration rubber mounts.
   ii) All indoor units coil shall have anti-corrosive coating
   iii) Installation manual.
   iv) Operation manual.
   v) Selected unit shall maintain NC 30-35.
   vi) All Indoor units shall be complete with IR with extended neck sensors and associated control caballing.
   vii) Refrigerant shall be Environment friendly R407C / R410A.

b. All units shall have cordless / corded remote. The remote should have following standard functions including but not limited to the following-
   i) Unit Start / Stop
   ii) Temperature setting.
   iii) Operating mode
   iv) 24 hour on/off timer
   v) Airflow swing activation.
   vi) Fan speed adjustment.
   vii) Memory restart.
   viii) Sleep mode.

3. Wall Mounted Indoor Units

a. Wall mounted indoor units shall be compact and stylish design that does not detract from the décor of the room.

b. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

c. Units shall have provision of adding drain pump kit if required and specified. Drain pumps shall be suitable to lift drain up to 1000 mm from the bottom of the unit.

d. Units shall be insulated with sound absorbing thermal insulation material. Noise level of unit at the highest operating level shall not exceed 35 dB(A), at a vertical distance of 1.5 m from the grille of the unit.

e. Units shall be supplied with maintenance free long life filter, Resin Net filter with Mold Resistance. The filter shall be easy to remove, clean & re install.

f. Unit grilles shall be washable with soap solution.

g. It shall be possible to set minimum 5 steps of discharge angle by remote controller.

h. It shall be possible to fit drain pipe from either side of the unit (left or right).

Copyright © Buro Happold Limited

i. Units shall be connected in series to a suitable outdoor unit and it shall be possible to operate the unit independently, through cordless remote control specified in the bill of quantities.

4. Ceiling Mounted Indoor Units

a. Ceiling mounted Hide away type indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned directly through duct collar and grille or through duct system specified in these tender documents.

b. Unit casing shall be Galvanized Steel Plate.

c. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

d. Units shall be insulated with sound absorbing thermal insulation material. The noise level of unit at the highest operating level shall not exceed 42 dB(A), at a vertical distance of 1.5 m below the units with duct connected to the unit.

e. Unit shall have thermal fuse for fan motor protection, in case of motor heating.

f. Units shall have provision to set external static pressure in three stages as per the system requirements depending on the air supply system.

g. Units shall be supplied with maintenance free long-life filter, Resin Net with Mold Resistance. The filer shall be easy to remove, clean and re-installed.

h. Units shall include a drain pump kit suitable to lift drain water up to 750 mm from the drain pipe opening as an optional equipment.

i. Units shall be connected in series to a suitable out door unit and it shall be possible to operate the unit independently, through corded/ cordless remote specified in the bill of quantities.

j. Unit shall be able to develop ESP of 15mm-25mm at the specified air quantities.

C. DX OUTDOOR FOR DUCTABLE UNITS (NOT APPLICABLE TO THIS PROJECT)

1. Scope :
Scope of this section comprises the supply, installation, testing and commissioning of outdoor units suitable for Constant Volume Refrigerant System.

2. General Requirements :

a. All outdoor units shall be supplied with the following from the factory:
   i) Clamp metal/ washer fixing plate/ sealing pads/ clamps/ screws/ washer for hanging bracket/ insulation for fitting.
   ii) Paper pattern for installation.
   iii) Installation manual.
   iv) Operation manual.

3. Materials and Construction :

a. Outdoors units of constant volume refrigerant flow system shall be compact air cooled type.

b. All compressors of the outdoor units shall be hermetically sealed scroll type.

c. Aluminum fins of condenser coils shall be provided with suitable factory installed protective coating for corrosion prevention.

Copyright © Buro Happold Limited

d. Outdoor units shall be suitable for up to 20m (straight length) refrigerant piping between outdoor unit & the farthest indoor units. Allowable level difference between outdoor unit & indoor units shall be 5 meter (minimum).

e. Outdoor units shall employ system of equal run time for all the compressors, inverter or on/ off type, within each out door unit – Single Module or Multi Module.

f. Outdoor units shall be suitable to operate within an ambient temperature range of – 5 Deg C to 50 Deg C in cooling mode .

g. Air cooled condensers shall have Axial Flow, horizontal throw fan, directly coupled to fan motors with minimum IP 55 protection. Outdoor unit condenser fans shall be able to develop external static pressure up to 8 mm of wg. Condensers will have elevation treatment louvers in front of them and it shall work without any deration of capacity.

h. The entire operation of outdoor units shall be through independent remote control of indoor units. No separate Start/ Stop function shall be required.

i. Refrigerant control in the outdoor unit shall be through Electronic Expansion Valve. Complete refrigerant circuit, oil balancing/ equalizing circuit shall be factory assembled & tested.

j. Noise level of outdoor units shall not exceed 60 dB (A) at a distance of 1.5 metre from the unit.

k. Coils of outdoor unit shall have blygold coating.

l. Outdoor units shall be complete with following safety devices:
   i) High pressure switch
   ii) Fan driver overload protector
   iii) Over current relay
   iv) Inverter overload protector
   v) Fusible plug

D. CEILING MOUNTED DUCTABLE INDOOR UNITS (NOT APPLICABLE TO THIS PROJECT)

a. Ceiling mounted Ductable indoor units shall be ceiling suspended with suitable supports along with anti-vibration mounts to take care of the operating weight of the unit, without causing any excessive vibration and noise. Cold air from the units shall be supplied to the area to be air conditioned, through duct system specified in these tender documents.

b. Unit casing shall be Galvanized Steel Plate.

c. Units shall have electronic expansion valve operated by microprocessor thermostat based temperature control to deliver cooling/ heating as per the heat load of the room.

d. Units shall be insulated with sound absorbing thermal insulation material. 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.

e. Unit shall have thermal fuse for fan motor protection, in case of motor heating.

f. Unit shall be able to develop external static pressure of 25 mm, at the specified air quantities.

g. Unit shall be connected in series to a suitable out door unit and it shall be possible to operate the unit independently, through corded/ cordless remote control specified in the bill of quantities.

h. Refrigerant shall be Environment friendly R407C / R410A.

i. All units shall have corded remote. The remote should have following standard functions including but not limited to-
   i) Unit Start / Stop
   ii) Temperature setting.
   iii) Operating mode
   iv) 24 hour on/off timer
   v) Airflow swing activation.

Copyright © Buro Happold Limited

vi) Fan speed adjustment.
vii) Memory restart.
viii) Sleep mode

E. SUPPLY/ EXTRACTION /

1. Scope
The scope of this section comprises the supply, erection, testing and commissioning of centrifugal, Tube axial, in-line and propeller type fans and roof mounted units conforming to these Specifications and in accordance with the requirement of Drawings ,Equipment schedule and schedule of Quantities.

Selected fans shall have sufficient static pressure to discharge / intake the air out and overcome the wind pressure at higher elevations

2. Capacity
The air-moving capacity of fans shall be as shown on Drawings, Equipment schedule and in Schedule of Quantities.

3. Type
Centrifugal fans and roof mounted units shall be of the type as indicated on Drawings, Equipment schedule and in Schedule of Quantities.

a. <u>Tube Axial Flow Fan</u>

Fans shall be direct driven **Tube axial** type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement as per approved for construction shop drawings.

Service Lift Lobby pressurization fans.

i) Casing shall be constructed of 14 gauge sheet steel. Fan casing and motor mount shall be of welded steel construction. Motor mounting plate shall be minimum 12 mm thick and machined to receive motor flange. Casing shall be provided with wide hinged doors which should open easily for removal of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be primed and finish coated with enamel paint.
ii) Rotor hub and blades shall be cast aluminum construction. Blades shall be die formed airfoil shaped for maximum efficiency and shall vary in width from hub to top to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5 mm. Rotor blades shall be whirl tested to a speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow values as specified and quoted.
iii) Motor shall be squirrel cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, suitable for 415 ± 6% volts 50 cycles, 3 phase power supply as per latest IS specifications. Motor nameplate horsepower shall exceed brake horsepower by a minimum of **20%.**. Motors shall be quiet operation and motor speed shall not exceed 1500 rpm. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires

Copyright © Buro Happold Limited

from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible conduit.

iv) Motor starters shall be automatic direct on line for rating up to 7.5 H.P. and automatic Star Delta for motors 10 HP & above. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.

v) Drive to fan shall be direct driven.

vi) Vibration Isolation: The assembly of fan and motor shall be suspended from the ceiling or mounted on walls by vibration isolators.

vii) Accessories : The following accessories shall be provided with all fans:
   I. Outlet cone for static pressure regain.
   II. Inlet cone.
   III. Fan silencers, if required.
   IV. Wire guards on fan outlet / inlet not connected to duct work and shall be made freely accessible for maintenance.

viii) Fans shall be factory assembled and shipped with all accessories factory-mounted. For smoke extraction fans, the gaskets shall be suitable for continuous operation in an air stream temperature of 250 °C for two hour or 300^0C for one hour.

b. <u>Centrifugal Fan</u>

Centrifugal fan shall be SWSI or DWDI Class I construction arrangement 3 (i.e. bearings on both the sides), complete with access door, squirrel-cage induction motor, V-belt drive, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

Housing shall be constructed of 14 gage sheet steel welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene / asbestos packing should be provided throughout split joints to make it air-tight.

18 gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.

NORMAL VENTILATION

i) Fans shall be non-overloading type. The fan capacity, static pressure, arrangement, width, direction of rotation, mode of discharge, etc. shall be as indicated in the schedule and in the applicable drawings or as required.

ii) Centrifugal fans shall be of the backward curved blade having a fan of total efficiency greater than 70%.

iii) Fan casings shall be constructed from 1.6 mm GSS construction and shall be able to permit withdrawal of impeller after fan installation. Fans shall be provided with flanged outlet connections. Permanent indication shall be provided to show the correct direction of rotation of the fan impeller. Fan casings shall be provided with air tight removable access panels. The sizes of access panels shall be such as to facilitate cleaning and maintenance of the impeller.

iv) Fan shaft shall be of EN - 8 steel constructions.

v) Impellers shall be of 2 mm thick mild steel or aluminum alloy of riveted welded or other approved construction, with spiders or hubs of robust design. Impeller shall be statically and dynamically balanced.

vi) Fans shall also be provided with heavy duty adjustable outlet dampers mounted in a separate frame.

vii) Fans shall be driven by a TEFC Sq. cage motor as per latest IS specifications. Motor ratings are only tentative and where a fan requires a higher capacity motor, the contractor shall clearly point out the requirements and make their offer accordingly. Motor ratings shall be at least 20% over limit load.

Copyright © Buro Happold Limited

viii) Motor starters shall be automatic direct on line for rating as indicated in electrical specification. The starters shall incorporate (a) thermal overload (b) under voltage protection (c) single phase preventer and are to be included in the prices of starter panels.

ix) All class I fans shall be provided with sleeve bearings with generous oil reservoir, drain plug, oil level indicator, etc. Class II and III fans shall be provided with heavy duty ball bearings.

x) Drive to fan shall be through oil resistant type belts with adjustable multi speed pitch motor pulley and approved belt guard. Pulleys shall be well balanced and properly aligned.

xi) Vibration Isolation : MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through Resistoflex or approved equal vibration isolators. The concrete foundation shall be at least 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings

2.2 PRODUCT SPECIFICATION

A. Piping

The scope of this section comprises the supply and lying of pipes, pipe fittings and support, testing and balancing of and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards. 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 smooth noiseless balanced circulation of fluids.

References:

- ASTM B68/1995 and ASTM-B75/1983- copper tubes used for Refrigerant purpose
- ASTM-E243 - Standard Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
- BS 864-Part II - Specification for Capillary and Compression Fittings for Copper Tubes
- BS EN 29453 - Soft solder alloys. Chemical compositions and forms
- BS 1723 - Brazing. Methods for non-destructive and destructive testing

1. **Refrigerant Piping – Materials and Construction:**

a. All refrigerant piping shall be of copper tubes conforming to ASTM B68 / 1995 and ASTM – B75/1983
b. Copper tubes shall be seamless, bright annealed with clean inside surface, free from all impurities.
c. Material of the tube shall be Phosphorous Deoxidized High Residual Copper with minimum 99.9% copper and 0.015% to 0.040% phosphorous.
d. Copper tubes shall have the following properties:

Sr. No.	Properties	Soft Annealed (ASTM-B68)	Hard Drawn (ASTM-B75)
a)	Tensile strength	30 ksi (min)	45 ksi (min)
b)	Elongation	40% (min)	Not required
c)	Hardness	60 HV5 (max.)	55 HV5 (min)
d)	Grain size	0.040 (min.)	Not required
e)	Expansion	40% (min)	Not required

Copyright © Buro Happold Limited

e. All tubes shall be 100% eddy current tested as per ASTM – E243 and test certificate submitted.
f. All tubes shall be carbon film tested and test certificate submitted. Maximum residual carbon shall be 0.1 mg/dm_2.
g. All tubes shall be deburred at both ends.
h. All tubes shall be free from carbon oxide or any other contaminant. Tubes for Non-CFC gas such as R134a, R410a, R600 etc. shall not be subjected to paraffin, wax, acids, chromium etc. in the factory and shall be cleaned & supplied without residues / oxides or carbon in the ID.
i. All tubes shall be pre-filled with nitrogen and capped on both sides before supply.
j. Tubes shall be ROHS (Restriction of hazardous substances) complied as per EC directives for hazardous substances including mercury, lead, cadmium & hexavelent chromium.
k. Contractor shall submit all test certificates including Hazardous Substance Compliance Certificate.
l. All hard tubes shall be printed with manufacturer's name, specifications, size, hardness at regular intervals.
m. Tubes shall be duly capped and packed in polythene bags. Capillary and compression fittings of copper and copper alloys shall conform to BS 864-Part II. Solder wire and brazing alloys shall conform to BS EN 29453 and BS 1723 respectively.
n. Selected piping material shall have sufficient corrosion resistance and shall work for at least 15 years without any change in property for sea climate.
o. Line velocities for pipe sizing shall be as follows:

a) Suction - 6 to 20 MPS
b) Discharge - 10 to 17.5 MPS
c) Liquid - 0.5 to 1.25 MPS

Contractor shall submit a schematic piping diagram for each type of refrigeration machine.

2. Condensate Drain Piping

All pipes to be used for condensate drain and fittings in apartments shall be high pressure UPVC conforming to relevant IS : 4985:2000 and pressure rating of 2.5 bar & Pressure Class-1. Pipes shall be joined using UPVC solvent cement confirming to IS: 4985. UCPVC fittings i.e. Tees, Elbows, Couplers, Unions, Reducers shall be conforming to IS: 7834 Part 1 to 8. AC condensate drain piping shall be indicated in Plumbing drawing. Corresponding drawing reference number shall be indicated on HVAC drawing. Drain piping as shown in the HVAC drawings or up to 10 meters from Indoor unit is in HVAC Contractors scope.

a. Proper slope (Minimum 1:100) shall be provided for better drainage. U trap shall be provided at outlet of the unit.
b. All condensate drain pipe sizes shall be as per BOQ & drawings.
c. All condensate drain piping shall be insulated as per the section "Insulation" as indicated in Schedule of Quantities.

B. Air Distribution

1. Scope

The scope of this section comprises supply fabrication, installation and testing of all sheet metal / Pre insulated , supply, installation, testing and balancing of all grilles, registers and diffusers. All to be in accordance with these specifications and the general arrangement shown on the Drawings.

2. Duct Materials

Galvanizing shall be Class VIII – light coating of zinc, confirming to IS-655-1963, nominal 120gm/Sq.M surface area and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at ran-

Copyright © Buro Happold Limited

dom by Employer's Representative/consultant shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

Fabrication of ducts shall be through well-conditioned Triplex lock former or multiple lock formers, conforming to relevant SMACNA Codes.

Rectangular Ducts G.S.	**External Pressure 250 Pa**		
	Duct Selection Length 1.2 Meters (4 feet)		
Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1-750 mm	26	C & SS	Nil
750 - 1000mm	26	4 Bolt Transverse Duct Connector - E (TDC) with built in sealant	Nil
1001-1200mm	24	4 bolt TDC - E	Nil
1201 - 1500 mm	24	4 bolt TDC - H	Nil
1501 - 1800 mm	22	4 bolt TDC - H	600mm from joint
1801 - 2100 mm	20	4 bolt TDC - J	600mm from joint
2101 - 2700 mm	18	4 bolt TDC - J	600mm from joint

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm

*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

3. Fabrication Standards & Equipment

c. All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.

d. Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.

e. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.

f. All edges to be machine treated using lock formers, flanges and rollers for turning up edges.

g. All ducts shall be fabricated and installed in workmanlike manner, generally conforming to relevant SMACNA Codes. Round exposed ducts shall be die-formed for achieving perfect circle configuration.

h. Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section "Insulation" and as indicated in Schedule of Quantities. Duct dimensions shown on Drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of Quantities.

i. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.

j. All exposed ducts up to 60 cm width within conditioned spaces shall have slip joints - or flanged joints. The internal ends of slip joints shall be in the direction of air flow. Ducts and accessories within ceiling spaces, visible from air conditioned areas shall be provided with two coats of mat black finish paint.

k. Changes in dimensions and shape of ducts shall be gradual. Air-turns (Vanes) shall be installed in all bends and duct collars designed to permit the air to

Copyright © Buro Happold Limited

make the turn without appreciable turbulence's. Ducts shall be fabricated as per details shown on 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.

l. 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 gage GSS / 16 gauge aluminum, thoroughly stiffened with 25 mm x 25 mm x 3 mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to
give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.

m. Plenums shall be panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards G S sheet and riveting shall be done from outside.

n. Self-adhesive rubber lining minimum 5 mm thick instead of felt shall be used between duct flanges and between duct and duct supports in all ducting installation.

o. All ducts shall be installed generally as per tender Drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor.

p. 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 Owner's site representative in all its parts and details.

q. 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 on 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.

r. 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 approval of Owner's site representative.

s. 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 centre. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. 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. Wherever use of metal insert plates is not feasible, 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.

t. Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building.

u. 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 fire sealant such as fire barrier mortar for complete sealing.

v. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by

Copyright © Buro Happold Limited

independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

w. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

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

y. Toilet exhaust duct shall be provided with goose necking as shown in design drawings.(if applicable)

4. Volume Control Dampers

a. All duct dampers shall be opposed blade louver dampers of robust 16 G GI construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.

b. The blades shall be coupled with the frame by external cross linkage. Linkage rods shall be coupled with hand locking quadrant with open & close marking. Bushings used are made of self-oiling nylon type.

c. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and easily accessible. Every damper shall have an indicating device clearly showing the damper position at all times.

d. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

e. The VCD shall be located in such a way handle operating mechanism shall be clearly visible though the trap door in the false ceiling. Damper position (open, ½, close) shall be marked on body & clearly visible through Access door in the false ceiling.

f. All linear bar grilles shall have collar damper for control purpose.

F. Pressure Relief / Gravity Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. Extruded aluminum Pressure relief / Gravity adjustable counterbalance horizontally mounted damper. This damper open by air pressure differential & close by gravity.

b. These dampers shall be rated for the velocities up to 2000 fpm & pressure up to 65mm of water gauge. They shall be rated for temperature 82 Deg C.

c. Damper shall consist of heavy gauge extruded aluminum channel frame 3.2mm thick, 79mm depth, blades from 1.8mm extruded aluminum, 19mm dia metallic axles turning in acetal bearings. Damper shall be equipped with extruded vinyl blade seal & internal U 3mm plated steel blade to blade linkage with counterbalance weights.

G. Motorized Fire & Smoke Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. All supply and return air ducts at fire wall crossings and at all floor crossings shall be provided with Motorized Fire & smoke damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555/UL555S 1995 tested by CBRI. 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. Control Panel shall have Form fit type of mounting, metal enclosure and guaranteed long life span.

b. Fire damper blades and outer frames shall be of 16G galvanized steel construction 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.

c. Fire resistance rating shall be on the either side of the Fire damper.

d. The electric actuator shall be energized upon receiving a signal from the Fire Alarm panel. The fire damper shall also close upon sensing temperature rise in supply air ducts through the electronic temperature sensor.

Copyright © Buro Happold Limited

e. Each damper shall be provided with its own control panel with actuator, mounted on the wall and suitable for 240 VAC supply. IP rating of the control panel shall be IP-56 for outdoor applications. This control panel shall be suitable for spring return actuator and shall have at least the following features:
   - Potential free contacts and remote alarm indication.
   - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
   - Fail safe position
   - Test and reset facility.
   - Indicating lights / contacts to indicate the following status:
   - Power Supply On
   - Alarm
   - Damper open and close position.

f. Control Panel shall be mounted on the external part of 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 its control panel. Control panel shall be wall mounted type.

g. MSFD shall be of low leakage design qualified to UL555S leakage class I. The combination of Fire & smoke dampers shall not exceed maximum temperature rating of 177 Deg C as per NFPA 90A.

h. As per NFPA-92A-6.4.3.6, the smoke-control mode shall be initiated within 10 seconds after an automatic or manual activation command is received at the smoke-control system.

i. The time necessary for individual components to achieve their desired state or operational mode once the component receives the signal shall not exceed the following time periods: Fan operation at the desired state: 60 seconds & Completion of damper travel: 75 seconds

j. 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 alarm / Building Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire alarm system contractor.

k. 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 energizing all the smoke detectors with the help of smoke.

l. HVAC Contractor shall provide Fire retardant cables wherever required for satisfactory operation and control of the Damper.

m. HVAC Contractor shall strictly follow the instructions of the Damper Supplier or avail his services at site before carrying out testing at site.

n. 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.

o. The Contractor shall also furnish to the Owner, the necessary additional spare control panels and temperature sensor (a minimum of 5% of the total number installed) at the time of commissioning of the installation.

H. Fire Dampers **(NOT APPLICABLE TO THIS PROJECT)**

a. Whenever a supply/return duct crosses from one fire zone to another, floor crossings it shall be provided with approved fire damper of at least equal to the fire rating of the wall or floor on which it is installed as per UL555 1995 tested by CBRI.

This shall be curtain type fire damper. For fire zoning kindly refer to the drawings issued by architect.

b. Fire damper blades shall be one piece folded high strength 21 gauge galvanised steel construction Body shall be in 20 G and sleeve in 16 G. In normal position, these blades shall be gathered and stacked at the frame head providing 100% air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through fusible link of temp 71 Deg C as specified in NFPA 90A.

c. Fire resistance rating shall be on the either side of the Fire damper.

Copyright © Buro Happold Limited

d. In case of fire, the intrinsic energy of the folded blades shall be utilized to close the opening. The thrust of the suddenly released tension shall instantly drive the blades down and keep it down without the use of springs, weights or other devices subject to failure.
   - Fire damper sleeves and access doors shall be provided within the duct in accordance with the manufacturer's recommendation.
   - The contractor shall also furnish to the Owner, the necessary additional fusible links (spares), as recommended by the manufacturer, at the time of commissioning of the installation.

I. Supply and Return Air Registers **(NOT APPLICABLE TO THIS PROJECT)**

a. Supply & return air registers shall be of either steel or aluminum sections as specified in schedule of quantities. Steel construction registers shall have primer Coat finish whereas extruded aluminum registers shall be either Anodized or Powder Coated as specified in Schedule of Quantities. These registers shall have individually adjustable louvers both horizontal and vertical. Supply air registers shall be provided with key operated opposed blade extruded aluminum volume control damper anodized in matt black shade.

b. The registers shall be suitable for fixing arrangement having concealed screws as approved by Architect. Linear continuous supply cum return air register shall be extruded aluminum construction with fixed horizontal bars at 15 Deg. inclination & flange on both sides only (none on top & bottom). The thickness of the fixed bar louvers shall be minimum 5.5 mm in front and 3.8 mm in rear with rounded edges. Flanges on the two sides shall be 20 mm/30 mm wide as approved by Architect. The grilles shall be suitable for concealed fixing. Volume control dampers of extruded aluminum anodized in black colour shall be provided in supply air duct collars. For fan coil units horizontal fixed bar grilles as described above shall be provided with flanges on four sides, and the core shall be & suitable for clip fixing, permitting its removal without disturbing the flanges.
   - All registers shall be selected in consultation with the Architect. Different spaces shall require horizontal or vertical face bars, and different width of margin frames. These shall be procured only after obtaining written approval from Architect for each type of register.
   - All registers shall have a soft continuous rubber/foam gasket between the periphery of the register and the surface on which it has to be mounted. The effective area of the registers for air flow shall not be less than 66 percent of gross face area.
   - Registers specified with individually adjustable bars shall have adjustable pattern as each grille bar shall be pivotable to provide pattern with 0 to +45 degree horizontal arc and up to 30 degree deflection downwards. Bars shall hold deflection settings under all conditions of velocity and pressure.
   - Bar longer than 45 cm shall be reinforced by set-back vertical members of approved thickness.

5. Linear Bar Grilles

Linear bar grilles shall be fabricated from aluminum, with 6.4mm wide bars on 12.5mm centers pressed into a notched steel retaining bar. The core can be either welded into the cuter frame, or, where the grille is used in a sill application, held in the outer frame by spring clips fixed to the core retaining bar.

The outer frame shall be 35mm deep and shall have a visible flange 25.4 mm wide. Mi-tred end caps shall be welded to give a near invisible joint.

The grill shall be complete with an opposed blade damper painted matt black, and shall be fixed with universal mounting brackets. Both the damper and the fixing brackets shall be accessible through the face of the grille.

Continuous grilles shall be provided with positive alignment strips, which fit into special

Copyright © Buro Happold Limited

keyways extruded into the frame of the grille to ensure clean unbroken lines.

All pressurization grilles shall be with Volume control dampers.

J. Linear Slot Diffusers **(NOT APPLICABLE TO THIS PROJECT)**

Linear Slot diffusers shall provide an unobtrusive continuous air diffusion with a pleasing aesthetic appearance. Hairline butt joints shall ensure clean unbroken linear runs for active and dummy sections. Slot width shall be 20 mm, unless otherwise indicated.

The diffusers shall be complete with pattern control blades, fully adjustable from face of diffuser through 180 degrees and shall be fitted with end caps at each end.

The diffuser members shall be constructed from high quality aluminum extrusions to BS 1474 while the pattern control blades shall be of black rigid PVC.

6. Louvers

a. Materials of Construction / Fabrication: Louvers shall generally be fabricated from extruded aluminum sections with mitered joints; unless otherwise stated or dictated by selection with minimum free area of 60%.

b. Finishing:

Louvers shall have anodized / polyester powder coated colored finish, selected to match with the surrounding architectural finishes.

c. Manufactures to submit performance data based on AMCA 500 - Test Method for Louvers, Dampers and Shutters

d. Construction :

Single angled louvers of 2.5 mm (12 gauge) thick, 100 mm (4 inch) deep blades set at 45° slope with centre baffle and return bend; set in heavy channel frame.

e. Accessories (for air intake):

i) Exterior flat flange for installation on walls

ii) 19 mm (3/4 inch) square mesh, bird screen; opposed blade, gang operated, volume control damper with removable key operator, adjustable from the grill face

iii) 100 mm (4 inch) panel type washable air filter

f. Accessories (for exhaust):

i) 13 mm (½ inch) square mesh, bird screen

Note- Grille, Diffuser, Register & Louver color code shall be as per the Architect approval. Sample is required for approval prior to ordering air side equipments.

C. INSULATION

1. Scope of this section comprises the supply, installation and testing of insulation as herein Specified and as per the requirements of Indian Standards.

2. General:

a. All tests like pressure testing should be completed and recorded and all systems approved by the Owner/ Consultants before insulation is applied to the equipment, piping and ducting. Insulation material shall be manufactured by approved manufacturers and shall be of the type intended for the services specified.

b. Insulation materials and finishes shall be inherently proof against rotting, mould, fungal growth and attack by vermin, be non-hygroscopic and in all respects be

Copyright © Buro Happold Limited

suitable for continuous use throughout the range of operating temperatures and within the environment indicated.

c. Unless otherwise indicated, all thermal insulating materials used within the building shall, tested in accordance with ISHRAE. Alternatively, all thermal insulating materials used within the building shall be noncombustible with a facing of combustible material provided the facing is not more than 0.8 mm thick. Thermal insulating materials used within the building shall be free from substances which in the event of a fire would generate appreciable quantities of smoke, noxious or toxic fumes. When instructed by the Owner/ Consultants, evidence of fire classification, obtained from an approved testing laboratory, shall be provided by the Contractor in order to certify that materials comply with this clause.

d. Thermal insulation shall be applied to air distribution ductwork and to components within distribution systems such as fans and cooler casings which convey conditioned air within plant rooms and to ductwork (including recirculation air ductwork) conveying warmed or chilled air through unconditioned spaces or the open air. Distribution system conveying treated fresh air and apartment toilet exhaust air shall be insulated.

e. Thermal insulation shall be applied to refrigeration pipe distribution system and to Components within distribution system.

f. Where thermal insulation is applied to the outside of pipes, ducts, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated in the documents, a water vapour barrier shall be provided. The vapour barrier shall be applied such that it will be continuous and will give protection to the whole surface of the insulation, which it will be protecting. The vapour barrier shall not be pierced or otherwise damaged by supports or by the application of external cladding. At points of support, means of load distribution shall be provided as necessary.

g. Adhesive Coating provides a protective finish for insulation refrigerant piping when applied in 2 coats with reinforcing fabric embedded between coats. When relative humidity exceeds 75% for continuous periods, additional vapor barrier protection is suggested. Adhesive Coating shall be produced under the classification and follow-up service of Underwriter's Laboratories, Inc. and meets NFPA 90A and 90B 25/50 requirements. Adhesive Coating shall not contain asbestos, lead, mercury, or mercury compounds. Coating shall be applied strictly as per the manufacturer's specifications.

h. At all points of support, both insulation and out covering shall be continuous and shall not be punctured or fouled by the supports. The insulation at supports shall be material of sufficient compressive strength to take the loads transmitted to the supports. The load- bearing insulation shall be extended on each side of the supports.

i. Only Aluminum tapes shall be allowed for the insulation joints and at the insulation Termination point.

j. At entries into buildings the weather-proofed insulation shall extend not less than 100 MM (4") beyond the inner face of the wall and be sealed to the satisfaction of the Architects/ Consultants.

3. Insulation material**:**

SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of the thermal and acoustic insulation for ducts and pipes.

Copyright © Buro Happold Limited

a. Material shall be insulated with flexible, closed cell, elastomeric, class 'O' nitrile rubber tubing or equivalent, of uniform density 60 t0 70 kg/cu.mt with the following properties:

   i. Thermal Conductivity:
      Less than 0.037 w/m.K at 0°C (as per BS 874 Part 2 1986 or DIN 52613).

   ii. Water vapour permeability:
      As per Din 52615, shall not exceed **0.15ng/m.sec.pa**.

   iii. Water absorption:
      Less than 1% by volume.

   iv. Fire performance:
      i) Surface spread of flame: Class 1 (BS476 Part 7, 1987)
      ii) Fire propagation (Total index) : Less than 12 (BS476 Part 6, 1989)

   v. The material shall be rated as **class 1**, as per **bs 476 part 7**. the rating as per **din 4102** shall be **b1**.

   vi. The **smoke density** of the material as per **AS-1530.3** shall not exceed **1.**

   vii. The material shall have a fire approval from CBRI/fire advisor (govt of india)/chief fire officer.

   viii. For providing uv protection the insulation shall be cladded with minimum 30 micron aluminum p e foil. The cladding shall be factory finished to avoid site work. The insulation material will be provided with self-adhesive covered peel off paper, (as an alternative).

   ix. Temperature Range:

      0°C to 50°C

   x. Performance:
      Guaranteed absence of condensation for all fluids at 5^0C in Mumbai ambient air conditions.

b. Pipes and ducts running at mechanical floors , outdoor or exposed on roof shall be, covered with 0.6mm (26 g) aluminum jacket on top of insulation.

c. Vapour barrier coating shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e outside the air conditioned area).

d. Drain piping shall be insulated with 9mm thick insulation applied in the same manner as specified for refrigerant piping.

e. All valves, fittings, strainers, etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

Copyright © Buro Happold Limited

Following thickness shall be followed while selecting material for different applications

Sr. No	Type Of Duct / Pipe	Area served	Insulation Material Properties		Protective Jacket
			Thick-ness In (mm)	Density (Kg / m^3)	
1	Supply and return Air AC Duct	Running In AC Area	19	60	Not Required
2	Supply and return Air AC Duct	Running In Non AC Areas such as enclosed in risers / shafts	25	60	Not required
3	Supply and return Air AC Duct	Running In Plant room / po-dium (Exposed Ducting) Ar-eas	25	60	Required, 26 G aluminium Clad-ding
4	Refrigerant pipes	Running In AC or Non AC Areas	19	60	
5	Refrigerant pipes	Running In Plant room / po-dium service balcony Areas	19	60	Required, 26 G aluminium Clad-ding

Copyright © Buro Happold Limited

4. Acoustic Insulation material:

   a. Connecting duct of Indoor unit shall be provided with internal acoustic lining for a distance of 3.0 meters (10'0") from the outlet with elastomeric nitrile rubber conforming to the following standards and specifications:

a) Thickness	: 19 mm for 3Mtrs. length of indoor unit outlets.
b) Density	: 60-80 kg/cum
c) Acoustic Values	: Greater than 1dB/m in the frequencies below 250Hz and greater than 5dB/m for frequencies 500 Hz and above in ducts of 600x500mm size
d) Temperature Range	: 5^0C to 50^0C
e) Fire Safety	: Non combustible in accordance with BS476 (1970) Class 'O' fire rating
f) General	: Should be chemically inert odorless, rot/ fungi/ vermin proof, should be dimensionally stable and should not be prone to sagging.

K. FIRESTOPPING AND SMOKE SEALS (NOT APPLICABLE TO THIS PROJECT)

1. For penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating services, provide through-penetration fire stop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

   a. Rated Systems: Provide through-penetration fire stop systems with the following ratings determined per ASTM E 814 or UL 1479 or NEC 300-21

   b. For through-penetration fire stop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

      - For exact details of fire sealing arrangement for fire dampers, kindly refer the drawings.
      - For floor penetrations with annular spaces exceeding 100 mm in width and exposed to possible loading and traffic, provide fire stop systems capable of supporting floor loads involved, either by installing floor plates or by other means.
      - For penetrations involving insulated piping, provide through-penetration fire stop systems not requiring removal of insulation.
      - Provide fire stop compounds for caulk, pour, trowel or pump application. Material must be capable of sealing openings around single or multiple pipes, cables against fire, smoke and toxic gases, and maintaining rating with a thickness no greater than the structure. Material shall be approved by Client's Representative and Local authorities.
      - For cable penetrations cementatious material and paint for cables up to 1 meter approx. can be used

2. Provide fire-resistive joint systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly in which fire-resistive joint systems are installed.

Copyright © Buro Happold Limited

a. Joint Systems in and between Fire-Resistance-Rated Constructions: Provide systems with assembly ratings equaling or exceeding the fire-resistance ratings of construction that they join, and with movement capabilities and L-ratings indicated as determined by UL 2079.

b. For fire-resistive systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84

END OF PART 2

Copyright © Buro Happold Limited

PART 3 EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare all the materials / Equipment, are according to the following:

1. Ensure that material / Equipment are dry and internally protected against rust and corrosion.

B. During Storage: Use precautions for material / equipment, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle equipment if size requires handling by crane or lift. Rig equipment to avoid damage to exposed parts

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored material from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect the material and equipment from moisture and dirt.

G. Store the material & equipment protected from direct sunlight. Support to prevent sagging and bending.

H. Delivery, Storage & Handling of material & equipment shall be strictly as per OEM / Manufacturer recommendation & guidelines.

I. Delivery, storage, Handling & Safe keeping shall be contractor scope of woks. Storage space shall be provided by the Client.

3.2 REFRIGERANT PIPE INSTALLATION

a. 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.

b. 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, clamps and hangers and be responsible for their structural sufficiency.

c. Wherever pipes pass through a fire rated wall / slab openings, the gaps shall be sealed with fire sealant of approved make.

d. All refrigerant piping shall be laid in cable trays. Direct clipping of pipes on ceiling or wall shall not be acceptable.

e. Refrigerant piping will be installed in following manner

- Cut the correct length of pipe with a tube cutter. End of the tube shall be cut at right angle to the axis. All burrs shall be removed with a file.
- Clean the outside and inside surface using cleaning pads or fine sand paper.

Copyright © Buro Happold Limited

- Apply water soluble thin film of flux to the tube and fittings, to prevent copper from oxidizing and to ensure that the molten solder bonds the tubes and fittings.

.

- Insert the tube into the fitting and push until the stop is reached. Wipe off excess flux with clean cloth.

- Apply heat on the assembled joints using lamps emitting clean, blue and soot free flame, till complete ring of the solder appears around the mouth of the fitting.

- Allow the joint to cool without disturbing the joint.

- Wipe off excess flux and other foreign matter.

3.3 CODENSATE DRAIN PIPE INSTALLATION

a. Design Drawings indicate schematically the size and location of drain 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.

b. Suitable U Trap shall be provided to condensate drain piping

c. Condensate drain should be shall be connected to nearest drain point as indicated in drawing.

d. The joints shall be properly sealed so that there is no leakage.

3.4 DUCT WORK INSTALLATION

a. All ductwork shall be constructed, reinforced, supported and installed in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible'.

b. All supply and return ductwork within 4.5 m of the air conditioning unit, measured from the unit along the duct, shall be 24 gauge sheet metal or heavier, but shall otherwise meet the aforementioned pressure and seal classes.

c. Ducts with a side dimension greater than 900 mm passing above acoustically rated areas (other than corridors) shall be fabricated from 18-gauge or thicker sheet metal. Ducts thinner than 22-gauge and pre-insulated ducts are unacceptable on this project.

d. Fire retardant canvass & rubber duct connectors with a minimum face length of 100 mm shall be Used between the ducts and fans or Ductable units.

e. Make all laps in the direction of air flow. Hammer down all edges and slips so as to leave smooth finished surface inside the ducts.

f. All ducts shall be braced and stiffened and shall be tight so that they will not breathe, rattle, vibrate or sag. Cross-break or transverse bead all rectangular ducts with heights or widths of 300 mm or larger.

g. Duct sealant shall be manufactured by tender specified approved manufacturer and of food grade quality. Brush joints with the compound before and again after assembly. Exposed ducts shall be sealed on the inner surfaces only.

Copyright © Buro Happold Limited

h. The Nexus or Ductmate 4-bolt duct connection maybe used to connect lengths of square or rectangular Duct. Intermediate reinforcing and longitudinal joints shall be as specified above. These proprietary connections shall be installed as shown in the Manufacturer's literature.

i. Seal the bottom and side joints of fresh air ducts or plenums to be watertight.

j. Flexible duct connections shall be of Class 1, corrugated aluminum flexible duct suitable for 1200C and 1.5 kPa and shall bear the 'building unit' label of Underwriters' Laboratories. Flexible duct connections shall be insulated with 25 mm fibre glass insulation with density of 24 kg/m3 complete with vapour barrier.

k. Bends in flexible ducts shall have centerline radius of not less than 1 1/2 x diameter. Collars to which flexible ducts are attached shall be a minimum of 50 mm in depth. Metal flexible ducts shall be attached using a minimum of three #8 sheet screws equally spaced around duct. Ducts larger than 300 mm diameter shall have a minimum of five #8 screws. Screws shall be located at least 12 mm from duct end. Insulation and vapour barriers on factory-fabricated ducts shall be fitted over cone connection and supplementally secured with a draw band.

l. Generally more durable and noise-resistant sheet metal ducts are preferable to flexible ducts in connecting ducts to diffusers or boxes. However, flexible ducts may be used under the following conditions:

    - Shown on drawings to allow easy location of diffusers does not pass through floors or fire walls and does not exceed 2.4 m in length. Flexible ducts shall not be installed in inaccessible locations, such as above gypsum board ceilings unless specific approval from the Consultant is obtained.

m. Where ductwork passes through a wall or floor, other than when a fire damper is required, pack around the duct using a fire resistant material to ensure a sound and air-tight joint. Cover the opening with sheet metal flange of the same metal thickness of duct, overlap opening on four sides by at least 38mm.

n. All supply linear bar grilles shall have string dampers for control purpose

o. Install ducts with fewest possible joints.

p. Install ducts with a clearance of 1 inch (25mm), plus allowance for insulation thickness.

q. Locate all sheet metal ducts where shown and size as shown. If changes of size or location of ducts are found necessary because of building construction, make a specific proposal for review by the Consultant prior to proceeding with the change.

r. Make changes of direction of horizontal ducts with elbows having an inside radius not less than the width of the duct. Make change of direction from horizontal to vertical duct with elbows having an inside radius equal to the depth of the duct. Where this is not possible due to the building construction, use turning vanes.

s. Provide access ports at convenient locations in all main ducts and main branch takeoffs with airtight covers and extension sleeves through insulation to allow air meter readings. Access ports shall be similar to 32 mm round openings as manufactured by E.H. Price or approved equal.

t. Provide flexible connections as specified at each building expansion joint, air handling unit and fan duct connection.

u. Paint visible internal surface behind each grille or register flat black.

Copyright © Buro Happold Limited

v. Where duct is acoustically lined, duct dimensions shown are net, inside of lining.

w. For duct construction refer to the chart given in section B.

x. Sheet thickness shall be in accordance with SMACNA standard.

y. All duct works support used for the project shall be factory galvanized.

z. Volume control damper joints with ductwork shall be flanged joint.

3.5 INSTALLATION OF DUCT THERMAL INSULATION

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.

2. The duct should be inspected and all joints should be sealed against leakages.

3. For ducts having width greater than 0.6m, heavy duty self-adhesive pins are to be applied to the duct at appropriate intervals (max 300mm) as per manufacturer‘s Installation Manual.

4. The duct should be covered with two coats of cold applied bitumen/CPRX or any other equivalent approved product.

5. The insulation of specific R-value and thickness should then be cut to appropriate length and stuck to the duct while the adhesive is still wet. For proper laying technique, refer to manufacturer’s Installation Manual.

6. All longitudinal joints and circular overlaps should be sealed with reinforced aluminum foil tape (50mm width) to make the installation leak proof. For large ducts, where adhesive pins have been used, speed washers/clips should be covered completely with Aluminum foil-tape to have an air-tight finish.

7. The insulation should then be secured over the duct using mechanically fastened nylon/steel straps (12mm/50mm) at appropriate intervals (max 1.2m).

8. After the installation the vapour retarding foil should be inspected and all tears should be sealed with Aluminum foil-tape to prevent air leakage.

3.6 INSTALLATION OF DUCT ACOUSTIC INSULATION

1. The duct surface should be cleaned with suitable solvents and rendered free from all physical and chemical impurities.

2. The duct should be inspected and all joints should be sealed against leakages.

3. Duct acoustic lining shall be provided for a distance of minimum 3 meters.

4. The inside surface for the ducts shall be covered with adhesive, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square.

5. Cut panels 60 x 60 cms of resin bonded fiber glass 25 mm thick shall be fitted in the squares.

6. These insulation panels shall be fixed to the sheet metal with cold setting adhesive compound. The inner most surface shall be covered with fiberglass tissue and 28 gage perforated aluminum sheet having at least 15 percent perforations.

7. The aluminum sheet shall be screwed to GI channels using cup washer and neatly finished to give true inside surface.

Copyright © Buro Happold Limited

3.7 INSTALLATION OF REFRIGERANT & CONDENSATE DRAIN PIPING INSULATION

Application of Refrigerant pipe insulation shall be as follows:

a. No insulation shall be applied until the pipe is satisfactorily pressure tested.

b. Pipe shall be thoroughly cleaned with wire brush and rendered free from all rust and grease.

c. Sleeve the insulation tube onto the pipes.

d. Seal all joints by proper adhesive.

e. For pipe insulation the material should be cut using a die /template to be provided by the manufacturer to ensure proper 45^0 angle is cut and the joining/overlapping of the insulation does not cause any buldging, or stretching

f. All valves, fittings, etc. for refrigerant piping shall be insulated to the same thickness as specified for the main run of pipes and applied generally in the manner specified above. Valves, joints, yokes and spindles shall be insulated in such a manner as not to cause damage to the insulation when the valves are used or serviced.

g. Vapour barrier coating shall be applied to insulated refrigerant pipework coming in contact with atmospheric conditions (i.e. outside the air conditioned area).

3.8 QUALITY ASSURANCE,INSPECTION, TESTING AND COMMISSIONING

A. Scope

The following quality assurance, inspection, testing and commissioning procedures shall be required to be carried out upon award of work.

i. Provide quality assurance program (QAP), works quality assurance program (WQAP), field quality assurance program (FQAP) and quality plan.
ii. Tests at manufacturer's works.
iii. Perform site tests and commissioning.

B. Submittals

i. After award of work following information shall be submitted.
   a. Quality Assurance Program (QAP)
   b. Works Quality Assurance programme (WQAP)
   c. Field Quality Assurance Programme (FQAP)
ii. For inspection and testing, submit inspection and testing procedures, programme, record sheets applicable at each hold point.
iii. After completion of testing, submit test records, packaging, transportation and storage instructions and methods.
iv. For site installation and commissioning, submit installation methods or procedures, notification and procedures for pre commission and commissioning.
v. After commissioning, submit site test records, as-built drawings, manufacturer's operation maintenance manuals and list of recommended spares and tools.

C. Quality Assurance Concept And Control

i. Minimum requirements for establishing and implementing a quality assurance programme shall be applied to all aspects of the work necessary for carrying out the contract. Quality assurance shall extend to material parts, components, systems and services as a means of obtaining and sustaining the reliability of critical items, operating performance, maintenance and safety.
ii. Acceptance of the Contractor's quality assurance programme does not relieve the Contractor's obligation to comply with the requirement of the contract document. If the pro-

Copyright © Buro Happold Limited

gramme is found to be ineffective, then the Owner's site representative reserves the right to request for necessary revisions of the programme.

iii. The Contractor is required to produce readily identifiable documentary evidence covering the extent and details of both his own and his sub contractor's quality assurances system as follows :
   a. Quality Assurance Program (QAP)
   b. Works Quality Assurance programme (WQAP)
   c. Field Quality Assurance Programme (FQAP)
   d. Quality Plan.

iv. These documents shall be prepared separately and submitted to the Owner's site representative at the time of starting the work.

v. Quality Plan and Manual shall be prepared by the Contractor for all items and services to be supplied, after the contract has been placed, but before commencement of fabrication, and shall be subject to evaluation and acceptance by the Owner's site representative before start of work.

D. Quality Assurance Manual (QAM)

i. The QAM shall be a general comprehensive document outlining the Contractor's basic organization, policies and procedures. The information to be given in the QAM shall include but not limited to :
   a. Quality Policy.
   b. Quality Assurance Programme
   c. Organization Structure showing inter relationships.
   d. Functional responsibilities and levels of authority.
   e. Lines of communication.
   f. Customer relations.
   g. Laboratory Facilities.

E. Works Quality Assurance Programme (Wqap)

i. The WQAP shall identify the Contractor's Quality Assurance Programme at works applicable throughout all phases of Contract performance, including design, procurement, manufacture, inspection and testing. It shall identify each of the programme elements to be designed, developed, executed and maintained by the Contractor for the purpose of ensuring that all supplies and services comply with this specifications.

ii. The information to be given under this programme shall include but not limited to : Organization and Responsibility.
   b. Contract Review.
   c. Design and Document Control.
   d. Procurement Control.
   e. Production Control.
   f. Control on Sub-contractors.
   g. In-process Quality Control and Traceability.
   h. Inspection and Testing.
   i. Control of Non-conformances.
   j. Corrective Action.
   k. Control of Inspection, Measuring and Test Equipment.
   l. Handling, Storage, Packaging and Delivery.
   m. Records.
   n. Quality Audits.
   o. After - Sales Servicing.

F. Field Quality Assurance Programme (Fqap)

i. This programme shall identify the Contractor's Quality Assurance Programme at site applicable throughout site construction, erection and commissioning. It is the underlying philosophy that the quality built into the product at works shall be maintained throughout the construction and commissioning stages.

II. While, in principle, the FQAP shall include the items discussed in WQAP, it shall, however, be approached differently to take into account site conditions.

III. The FQAP shall include, but not limited to the following information :
   a. Organization and responsibility.
   b. Control of Drawings and Documentation.

Copyright © Buro Happold Limited

c. Product Checklist.
d. Control and Traceability of Purchased materials and services.
e. Receipt Inspection of materials at site.
f. Material Storage Control.
g. Inspection and Examination Procedures.
h. Control of Painting and Insulation Works.
i. Pre-commissioning.
j. Commissioning.
k. Control of Non-conformances.
l. Corrective Action.
m. Control of Inspection, Measuring and Test Equipment.
n. Records.
o. Complétion Documents.
p. List of recommended spares and tools.
q. Personal Training.
r. Servicing during Defects Liability Period.

G. Quality Plan

I. The contractor shall be required to prepare manufacturing and construction/erection quality plans for all equipment items and services. The quality plan shall also define the involvement of Owner's site representative in the inspection and test programme.

II. The Quality Plan shall incorporate as appropriate :

a. Charts indicating flow of materials, parts and components through manufacturing quality control inspection and test to delivery and erection.

b. The charts shall indicate the location of hold points for quality control, inspection and test beyond which manufacture shall not continue until the action required by the hold point is met, and the documentation required is generated.

c. The control documents associated with each hold point, i.e. drawings, material, specification, Works Process Schedule (WPS), Process Quality Records (PQR), quality control methods and procedures and acceptance standards.

H. Site Quality Control Section

I. The Contractor's Quality Control (Q.C.) section shall be headed by an experienced Quality Control Engineer. He shall be assisted by other supervisors. The section shall be an independent one, reporting to the contractor's Site Manager only on administrative matters, but otherwise under full control by the Contractor's Corporate Quality System Management.

II. The Contractor's Q.C. Section shall liaise closely with the Owner's site representative in charge of Quality Assurance/Quality Control, and to whom it shall give fullest cooperation. It is the underlying principle of this contract document that while the Contractor's Q.C. Engineer implements the Contractor's Quality Programme, the adequacy and effectiveness of that implementation shall be audited by the Owner's site representative whose recommendations on improving or maintaining quality shall be acted upon promptly by the Contractor's Q.C. Section.

I. Inspection And Testing

I. All equipment and components supplied may be subjected to inspection and tests by the Consultant/ Owner's site representative during manufacture, erection/installation and after completion. The inspection and tests shall include but not be limited by the requirements of this contract document. Prior to inspection and testing, the equipment shall undergo pre-service cleaning and protection.

II. Tenderers shall state and guarantee the technical particulars listed in the Schedule of Technical Data. These guarantees and particulars shall be binding and shall not be varied without the written permission of the Owner's site representative.

III. No tolerances shall be allowed other than the tolerances specified or permitted in the relevant approved Standards, unless otherwise stated.

IV. If the guaranteed performance of any item of equipment is not met and / or if any item fails to comply with the specification requirement in any respect whatsoever at any stage of manufacture, test or erection, the Owner's site representative may reject the item, or defective component thereof, whichever he considers necessary; and after adjustment or modification as directed by the Owner's site representative, the contractor shall submit the item for further inspection and /or test.

Copyright © Buro Happold Limited

V. The approval of the Owner's site representative of inspection and/or test results shall not prejudice the right of the Owner's site representative to reject an item of equipment if it does not comply with the contract document when erected, does not or prove completely satisfactory in service.

VI. The Contractor shall be responsible for the timely transmission of the relevant and appropriate sections of the contract document to manufacturers and sub-contractors for the proper execution of all tests at their works as per contract specifications.

J. Tests At Manufacturer's Works

I. All tests to be performed during manufacture, fabrication and inspection shall be agreed with the Consultant/ Owner's site representative prior to commencement of the work. The Contractor shall prepare the details of the schedule and submit these to the Consultant/ Owner's site representative 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 Consultant/Owner's site representative who will mark in the appropriate spaces his intention to attend or waive the invited tests, or inspections.

II. A minimum of twenty-one days' notice of the readiness of equipment for test or inspection shall be provided to the Owner's site representative by the Contractor (whether the tests be held at the Contractor's of Sub-contractor's works). The subject items should remain available for Owner's site representative inspection 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 Owner's site representative to carry out the necessary inspection and testing of the Plant.

III. No plant 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 Owner's site representative or approved for shipment, or alternatively inspection has been waived.

IV. 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 Owner's site representative 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.

V. The Consultant/Owner's site representative 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 to date.

VI. 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 Owner's site representative.

VII. These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Owner's site representative 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.

VIII. 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 from complete with index and four copies of each volume shall be supplied to Consultant/ Owner's site representative.

IX. Stage wise inspection of equipment in factory in waived.

K. Performance Tests At Manufacturer's Woks

i. 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.

ii. Fans, compressor, and other rotating equipment shall be given full load tests, and run to 15% over speed for 5 minutes 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.

iii. The Contractor shall submit single line diagrams including the layout of the Plant together with the location of test instrumentation and the principal dimensions of the lay-

Copyright © Buro Happold Limited

out. 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 Owner's Site Representative.

iv. 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 Consultant/ Owner's site representative.

v. 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.

3.9 IDENTIFICATION & LABELLING

A. **Color Scheme**

Description	Standard and Reference	Lettering Colouring
Exposed duct Work	To architect's	
Air-Conditioning Duct Work	BSS 111 Pale Blue	Black
Ventilation Duct work	BSS 111 Pale Blue	Black
Conditioner Casings, Fan Coil Units, Filter Plenums	BSS 111 Pale Blue	Black
Electrical (Conduit Ducts and Motors)	BSS 557 Light Orange	Black
Drains	Black	White
Beltguards	Black and Yellow diagonal stripes (45 25 mm wide)	
Switchboards - Exterior / Interiors	BS 366 Light Beige White	
Machine Bases, Inertia Bases and Plinths	Charcoal Grey	

B. Identification Of Services For Piping Services

Lubricating	14 E 53
Drainage and Other Fluids:	Basic Colour Only

Copyright © Buro Happold Limited

Electrical Services:	Basic Colour Only

In addition to the color bands specified above all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows :-

Condensate	CN

Pipe shall have the letters F and R added to indicate flow and return respectively as well as directional arrows.

Pipe Line Contents	**BS.4800 Colour Reference**	**Colour**
Drainage	00 E 53	Black
Electrical	06 E 51	Orange

Color Code indicator bands shall be applied as color bands over the basic identification color in the various combinations as listed below

Pipe Line Contents	**Colour Bands to BS.4800**
Cooling	00 E 55
Condensate	04 D 45 /14 E 53 /04 D 45

C. **Duct Work Services:**

For Duct work services and its insulation the colors of the triangles shall comply with BS .1710:1971. The size of the symbol will depend on the size of the duct and the viewing distance but the minimum size should not be less than150 mm length per side. One apex of the triangle shall point in the direction of airflow.

Services	**Colour**	**BS.4800 Colour Reference**
Conditioned Air	Red and Blue	04 E 53 / 18 E 53
Ward Air	Yellow	10 E 53
Fresh Air	Green	14 E 53
Exhaust / Extract / Re circulated Air	Grey	AA 0 09
Cold Supply Air	Blue	18 E 53

In addition to the color triangles specified above all duct work shall be legibly marked with black or white letters to indicate the type of service ,identified as follows:-

Supply Air	S
Return Air	R

Copyright © Buro Happold Limited

Fresh Air	F
Exhaust Air	E

The color banding and triangles shall be manufactured from self adhesive cellulose tape, laminated with a layer of transparent ethyl cellulose tape.

3.10 TESTING, ADJUSTING AND BALANCING

A. Scope

a. Testing, adjusting and balancing of Apartment heating, ventilating and air-conditioning systems at site.

b. Testing, adjusting and balancing of HVAC DX system at site.

Comply with current editions of all applicable practices, codes, methods of standards prepared by technical societies and associations including:

ASHRAE : 2007 HVAC Application.

SMACNA : Manual for the Balancing and Adjustment of air distribution system.

B. 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.

C. Definitions

a. Test : To determine quantitative performance of equipment.

b. Adjust : To regulate for specified fluid flow rates and air patterns at terminal equipment (e.g. reduce fan speed, throttling etc.)

c. Balance : To proportion within distribution system (sub mains, branches and terminals) in accordance with design quantities.

D. 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 PMC about his readiness to conduct the TAB procedures in the format given in these specifications.

E. Description Of System And Requirements

Adjust and balance the following system to provide most energy efficient operation compatible with selected operating conditions.

a. All supply, return and outside air systems.

F. Air Systems

I. HI-wall Split / Ductable indoor Units Performance

The TAB procedure shall establish the right selection and performance of the indoor units with the following results :

a. Air-IN DB and WB temperature.(degree Fahrenheit)
b. Air-OUT DB and WB temperature.(degree Fahrenheit)
c. Dew point air leaving. (degree Fahrenheit)
d. Sensible heat flow.(Btu/hr)
e. Latent heat flow.(Btu/hr)
f. Sensible heat factor.
g. Fan air volume.(cfm)
h. Fan air outlet velocity.(fpm)
i. Fan static pressure.(in wg)
j. Fan power consumption.(kw)
k. Fan speed.(rpm)

II.Air distribution

Both supply and return air distribution for each indoor units and for areas served by the indoor units shall be determined and adjusted as necessary to provide design air quanti-

Copyright © Buro Happold Limited

ties. It shall cover balancing of air through main and branch ducts utilizing telescoping probes of Electronic Rotating Vane Anemometers and Accubalance for grilles and diffusers.

III. 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 :

a. All outside air intake, return air and exhaust air dampers are in proper position.
b. All system volume dampers and fire dampers are in full open position.
c. All access doors are installed & are air tight.
d. Grilles are installed & dampers are fully open.
e. Provision and accessibility of usage of TAB instruments for traverse measurements are available.
f. All windows, doors are in position.
g. Duct system are of proper construction and are equipped with turning vanes and joints are sealed.
h. Test holes and plugs for ducting.

G. Readiness For Commencement Of Tab

Before starting of any of the tests, the readiness to do so should be recorded as per the prescribed check list.

H. Tab Instruments

I. Air Measuring Instruments

a. For measuring DB and WB temperature, RH and dew point, microprocessor based TSI USA make Veloci Calc 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.
b. For measuring Air velocity, DB temperature and Air volume, TSI USA make VelociCalc meter model 8386/ 8345 or equivalent shall be used. It shall be able to provide instant print out of recorded Air volume readings.
c. Pitot tube.
d. Electronic Rotary Vane Anemometer TSI make or equivalent.
e. Accubalance Flow Measuring Hood TSI make or equivalent.

[All above instruments shall have a valid certification from a reputed testing institution.

II. Rotation Measuring Instrument

Electronic Digital Tachometer.

IV. Temperature & RH Measuring Instrument

TSI VelociCalc model 8386 / VelociCalc model 8345 or equivalent.

V. Electrical Measuring Devices

a. Clamp on Volt ammeter.
b. Continuity Meter.

VI. Vibration and Noise Levels

Vibration and alignment field measurements shall be taken for each indoor units / outdoor units 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 PMC.

Sound level readings shall be taken at ten (10) locations in the building as selected by the PMC. 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 test shall be performed in the presence of PMC/Consultant.

Copyright © Buro Happold Limited

I. Testing & Commissioning of Lift well Pressurization System-

1) As the name implies, the intent is to prevent smoke from migrating into the elevator shaft by pressurizing the shaft with respect to the rest of the building. Typically the pressure differentials are created by actively controlling dedicated supply fans and isolation dampers (if applicable) to supply the elevator shaft with 100% outdoor air.

Pre functional checklist items include, but are not limited to, the following:

a) Fan systems and isolation dampers (if applicable) are installed per contract documents and manufacturer's installation instructions.

b) Control system point-to-point checkout complete to ensure all fan and damper input/output points are wired correctly.

c) Normal power, and emergency if applicable, is provided to each fan and damper assembly at proper voltage.

d) All fan systems have been balanced per the contract documents.

e) All safeties and interlocks, especially fan status and high pressure cut-out, are installed and function per contract documents.

2) Typically, isolation dampers will open (if applicable) and supply fan will be commanded ON automatically upon an event signal. In order to test proper operation of the elevator shaft pressurization system, initiate an event signal and verify the following:

a) All isolation dampers open (if applicable) and supply fans turn ON.

b) The pressure differential exceeds the value required by code. (Measure and record pressure differential across each elevator door with all doors closed.) Note that stack effect; wind speed and direction; and outdoor temperature may all influence measured pressures and system balance.

3.11 STATUTORY AUTHORITIES TESTS AND INSPECTIONS

A. As and when notified in writing or instructed by the client/ consultant, the contractor shall submit shop drawing and attend all tests and inspections carried out by Local Authorities and other Statutory Authorities shall forthwith execute free of charge any rectification work ordered by the client/ consultant as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

B. The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

C. The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the client/consultant for checking before submission. The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within six months after the award of the Contract but not less than six weeks before the inspection. The client/consultant may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

D. The Contractor shall notify the client/consultant at least seven days in advance of his application for local Authority tests and factory inspections / visits for major equipments.

On receipt of a confirmed date for test and inspection the Contractor shall inform the client/consultant without delay.

Copyright © Buro Happold Limited

3.12 PRELIMINARY COMMISSIONING CHECKS

A. Ensure that all equipment & system is thoroughly cleaned, lubricated and checked for serviceability before setting to work. Particular attention is drawn to the removal of building debris from the pipe work systems.

B. Special attention is drawn to the need for thoroughly flushing out all pipe work systems to ensure that all foreign matter is removed.

C. All automatic controls and safety devices shall be inspected and checked for service ability before the working fluid or electricity is applied to the system.

3.13 COMMISSIONING

A. When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all system in the entire installation. Special attention shall be paid to the following items:

1. That all valves, switches, controls, etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.
2. That all apparatus is silent in accordance with the requirements of this Specification.
3. That all instruments are correctly calibrated and read accurately.
4. That all services are tested in accordance with the details in the relevant clauses of this Specification.

3.14 FINAL ACCEPTANCE TESTS

A. Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final acceptance tests in accordance with a programme to be agreed with the client/consultant.

B. Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performance is obtained.

C. Where acceptance tests are required by the relevant Authorities having jurisdiction, these tests shall be carried out by the Contractor prior to the issue of Completion Certificate to the acceptance of the Authorities.

3.15 REJECTION OF PLANT

A. Any item of plant or system or component which fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site may be rejected by the client/consultant either in whole or in part as he considers necessary/appropriate. Adjustment and/or modification work as required by the client/consultant so as to comply with the Authority's requirements and the intent of the Specification shall be carried out by the Contractor at his own expense and to the satisfaction of the Authority/client/consultant.

B. After works have been accepted, the Contractor may be required to carry out assist in carrying out additional performance tests as reasonably required by the Employer.

3.16 HANDING OVER OF DOCUMENTS

A. All testing and commissioning shall be done by the Contractor to the entire satisfaction of the Client and all testing and commissioning documents shall be handed over to the Client.

B. The Contractor shall also hand over all maintenance and operation manuals, all certificates and all other documentation as per the terms of the contract to the Client.

3.17 MAINTENANCE DURING DEFECTS AND LIABILITY PERIOD (DLP)

A. General

1. Provide the following free maintenance for a period of Eighteen (18) months after handing over the HVAC System to client (i.e. during warranty period)

Copyright © Buro Happold Limited

2. Examinations: Bi-Weekly, including adjustments, cleaning and lubrication of equipment.
3. Replacement: Replace components when required, using parts produced by original manufacturer.
4. Spare Parts: Provide necessary spare parts; maintain locally an inventory of all wearing parts of the system.
5. Call Backs: Provide 24-hour emergency call back service at no expense to Owner.
6. Records: Maintain complete maintenance records including check charts, lubrication logs and activity logs; provide check charts and activity logs.

B. Extended Service Contract

1. At time of Bid, submit cost for full maintenance contract i.e. after the expiry of 18 month warrantee and free maintenance period.
2. Contract Term: Upon expiration of new installation, free maintenance, provide full maintenance service for five (5) years, including spare parts. Optional price for the maintenance to be provided for each year.
3. Service: Provide examinations, logs, replacements and spare parts as specified for maintenance, including cleaning of tanks, equipment and machinery spaces required to maintain the water output quality and quantity as per design.

END OF PART 3

Copyright © Buro Happold Limited

GUARANTEE PROFORMA

GUARANTEE FOR APARTMENT-HVAC SYSTEM INSTALLATION

We hereby guarantee the year round Apartment- HVAC System which we have installed in the building described below :

Building : ARANYA – NORTH TOWER

Location : Byculla, Mumbai

Owner : M/s Piramal

For a period of **18 Months** from the date of acceptance of the total installation, WE AGREE TO repair or replace to the satisfaction of the Owner, any or all such work that may prove defective in workmanship, equipment or materials within that period, ordinary wear and tear and unusual abuse or neglect excluded, together with any other work, which may be damaged or displaced in so doing. In the event of our failure to comply with the above mentioned conditions within a reasonable time, after being notified in writing, we collectively and separately, do hereby authorize the Owner to proceed to have the defects repaired and made good at our expense, and we shall pay the cost and charges thereof, immediately upon demand.

WE ALSO HEREBY UNDERTAKE to test the entire installation in first SUMMER, WINTER AND MONSOON on following the completion of the installation, to check and do everything necessary to ensure that the specified design conditions and functional requirement are met, that system is properly balanced, that all controls are calibrated accurately, and that all units are functioning satisfactorily.

SIGNATURE OF CONTRACTOR
For Apartment HVAC SYSTEM

DATE

SEAL

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – C & D

SCHEDULE OF EQUIPMENTS

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
Volume 02	B.1	HANGERS AND SUPPORTS		
		PART 1 - GENERAL		
		1.1	SUMMARY	1
		1.2	PERFORMANCE REQUIREMENTS	1
		1.3	SUBMITTALS	2
		1.4	QUALITY ASSURANCE	3
		PART 2 - PRODUCTS		
		2.1	PIPE HANGERS	4
		2.2	FLOOR SUPPORTS	5
		2.3	WALL SUPPORTS	5
		2.4	VERTICAL PIPING SUPPORTS	5
		2.5	DISTRIBUTION PIPING IN SHAFTS AND CHASES	6
		2.6	PIPE ANCHORS	6
		2.7	HANGER RODS AND ACCESSORIES	7
		2.8	BUILDING ATTACHMENTS	8
		2.9	SUPPORT INSULATORS	8
		2.10	TRAPEZE PIPE HANGERS	8
		2.11	METAL FRAMING SYSTEMS	8
		2.12	THERMAL-HANGER SHIELD INSERTS	9
		2.13	FASTENER SYSTEMS	9
		2.14	PIPE STANDS	10
		2.15	EQUIPMENT SUPPORT	10
		PART 3 - EXECUTION		
		3.1	HANGER AND SUPPORT INSTALLATION	13

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
VOLUME 02	B.1	3.2	PIPEWORK SUPPORT SPACINGS	13
		3.3	ADJUSTING	17
		3.4	CLEANING AND PAINTING.	17

Copyright © Buro Happold Limited

PART 1 - GENERAL

1.1 SUMMARY

A. Contractor shall allow for design , fabrication, installation and coordination with other trades for hangers, supporting system and expansion joints(for expansion joints refer section B.3) for the installed system

B. Section Includes:

1. Pipe hangers, Floor & wall supports, Vertical piping supports
2. Distribution piping in shaft and chases
3. Pipe anchors
4. Hanger rods and access**o**ries
5. Building attachments and support insulators
6. Trapeze pipe hangers.
7. Metal framing systems.
8. Thermal-hanger shield inserts.
9. Fastener systems.
10. Pipe stands.
11. Pipeline Anchors & Guides.
12. Equipment supports.
13. Steel ropes & wires

1.2 PERFORMANCE REQUIREMENTS

A. Design: Design hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7 or BS EN 13480.

C. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

D. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

E. The hangers and supporting system for the building shall be take care of the following effects

a. Seismic Movements(Earthquake case)
b. Effect of Wind - Building swing (Wind case)
c. Building settlement
d. Expansion and contraction
e. Column shortening for any given floor(including effects of creep and shrinkage)

Copyright © Buro Happold Limited

F. Following data to be used while designing the hangers and supporting

a) ***Lateral Displacement***

Floor	***Earth quake case***		***Wind Case***	
	X-DIRN		***Y-DIRN***	
	Maximum (mm)	***Interstorey (mm)***	***Maximum (mm)***	***Interstorey (mm)***
ROOF	*267*	*4*	*535*	*10*
LEVEL 49	*177*	*4*	*360*	*10*
LEVEL 30	*96*	*4*	*195*	*10*
LEVEL 11	*31*	*3*	*62*	*5*
BASEMENT-1	*0.1*	*0*	*0.3*	*5*

b) **Settlement Of the Building-**

Maximum Deflection *12* *mm*

Minimum Deflection *0* *mm*

Note: Success full bidder / contractor shall verify the above data with structural engineer before proceeding for the designing / selection of hangers and supporting system.

c) Column shortening for any given floor(including effects of creep and shrinkage) shall be 3mm floor Minimum.

1.3 SUBMITTALS

A. Contractor shall submit following calculations for hangers and supporting system for Consultant's review, Calculations shall be prepared and sealed by a qualified Structural Engineer and shall show compliance with the loading requirements. Furnish engineering calculations including, but not limited to, the following items.

1. Hanger design criteria
2. Point loadings.
3. Wall and column attachments.
4. Embedment's for supporting for all horizontal and vertical piping.
5. Stresses and forces on mountings and hangers from expansion and contraction of piping.
6. Engineering calculations to demonstrate compliance with requirements as specified in clause 1.2-E and 1.2-F above.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show fabrication and installation details and for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.
5. Detail fabrication and assembly of trapeze hangers.
6. Design Calculations.

D. Welding certificates.

Copyright © Buro Happold Limited

1.4 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel." Alternatively comply with BS 2971.

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code. Alternatively comply with HVCA code of practice TR/5, skilled craftsmen up to class 2 standard are required.

C. Clevis or Band Hangers used for sprinkler system piping shall be UL listed and labeled.

D. Unless otherwise stated, all steel components shall be galvanized post manufacture, according to ASTM B633 SC3.

E. Test certificate for heat aging at 1200C, as per ASTM D2240, shall be furnished for EPDM gasketting used as separation between pipe and hangers.

F. Each hanger and support shall have the manufacturer’s name and part number stamped on it.

G. All hangers and supports shall be manufactured at an ISO 9001 certified facility. Manufacturer’s ISO certificate, clearly stating Pipe Supports within the scope of registration, shall be furnished.

Copyright © Buro Happold Limited

PART 2 - PRODUCTS

2.1 PIPE HANGERS

A. Piping up to DN 50 (2 inch): Adjustable galvanised steel band hangars. Copper plated or EPDM LINED hangers shall be used piping.
Reference - ISHRAE Installation guide,Type-10, 7

B. Ferrous piping up to DN 150 (6 inch): Adjustable galvanised steel clevis hanger. Galvanised steel pipe covering shield shall be used for insulated piping, especially for HVAC services (alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide Type-1

C. Ferrous piping over DN 150 (6 inch) - HVAC Services: Adjustable, steel pipe roll with steel axle, steel sockets, lock nuts etc. Rubber support inserts and galvanised steel insulation protection shield shall be used at support points on insulated piping.
Reference - ISHRAE Installation guide Type 44

D. Copper piping (non-insulated): Adjustable swivel ring galvanised steel band hanger with EPDM lining.
Reference - ISHRAE Installation guide,Type-10, 7

E. Copper piping (insulated): Adjustable swivel ring galvanised steel band hanger with steel pipe covering shield (alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide,Type-10, 7

F. Plastic piping up to DN 150 (6 inch): Split ring type EPDM lined steel pipe clamp with welded suspension nut.
Reference - ISHRAE Installation guide,Type-10, 7 with rubber strips

G. Multiple hangers for pipes up to DN 75 (2 inch): Electro galvanized U-strap pipe clamps. with elastomer lining placed on painted / galvanised steel angle / channel suspended from ceiling.
Reference - ISHRAE Installation guide Type-1

H. Multiple Hangers for Combination of services: Hot dip galvanised steel, continuous channels cast-in in concrete or suspended from ceiling. Pipe hanger / supports shall be as specified before (make appropriate selection).

2.2 FLOOR SUPPORTS

A. Ferrous piping up to DN 150 (6 inch): Adjustable pipe stanchion saddle support complete with U-bolt, stand pipe with adjuster and floor flange, use galvanised steel pipe covering shield for insulated piping.(alternatively rubber support inserts shall be installed at support points to prevent crushing of insulation).
Reference - ISHRAE Installation guide Type-37

B. Ferrous piping over DN 150 (6 inch): Steel pipe roll with steel base and stand. RCC / structural steel pedestals shall be provided, as appropriate, to locate the base. Rubber support inserts shall be installed at support points to prevent crushing of insulation. Galvanised steel insulation protection shield shall be used outside rubber support inserts on roller based supports.
Reference - ISHRAE Installation guide Type-37, 44

Copyright © Buro Happold Limited

C. Copper piping (non-insulated): Adjustable pipe stanchion saddle support complete with rubber lined U-Bolt, stand pipe with adjuster and floor flange.
Reference - ISHRAE Installation guide Type-37

D. Copper piping (insulated): Adjustable pipe stanchion saddle support complete with U-bolt, stand pipe with adjuster and floor flange and galvanised steel pipe covering shield. Rubber support inserts shall be installed at support points to prevent crushing of insulation, as appropriate.
Reference - ISHRAE Installation guide Type-37

E. Plastic piping Same as that of ferrous piping.

2.3 WALL SUPPORTS

A. Multiple hangers for plumbing pipes up to DN 75 (2 inch): Electro galvanised U-strap pipe clamps with elastomer lining placed on painted / galvanised steel channel attached to wall.
Reference - ISHRAE Installation guide Type-12

2.4 VERTICAL SHAFT PIPING SUPPORTS

A. Ferrous piping up to DN 150 (6 inch): Galvanised steel riser clamps and / or offset pipe clamp. Rubber support inserts shall be used at the supports for insulated piping.

B. Ferrous piping over DN 150 (6 inch): Designed and fabricated at site with the following components:

1. Gusset plates with integral bearing plates (minimum thickness equal to that of the pipe) welded to pipe
2. Cross channels resting on permanent construction (floor slab / block work); offset to accommodate piping insulation and attached to each other by steel flats welded at both ends
3. `Z' cleats welded on the cross channels at the ends of the bearing plates to restrict movement
4. Heavy duty vibration isolation pads (50 durometer) placed under bearing plates for vibration / thermal isolation
5. Vapour barrier sealed around the gusset plate with mastic sealant

C. Plastic / copper non-insulated piping up to DN 75: U-bolts with rubber sleeve / or U-strap clamps with rubber lining attached to hot dip galvanised channel sections anchored to wall.
Reference - ISHRAE Installation guide Type-12

D. Plastic / copper piping over DN 75 (3 inch) - Non-insulated: Galvanised steel offset riser clamp with EPDM lining; resting on steel sections

E. Plastic / Copper piping over DN 75 (3 inch) - Insulated: Galvanised steel offset riser clamps over rubber support inserts installed at support points to prevent crushing of insulation.

F. Plastic piping: Zinc coated clip with internally threaded neck, sleeve, back nut, coach (wood) screw and plastic wall insert

Copyright © Buro Happold Limited

2.5 DISTRIBUTION PIPING IN SHAFTS AND CHASES

A. Copper piping: Semi circular galvanized steel straps with ears for attaching to walls.

2.6 PIPE ANCHORS

A. Shall be provided in suitable locations to control the direction and effects of movement of the pipework systems and to resist stresses and loading on pipework due to forces acting on the pipework system. Use materials similar or compatible with the pipework systems. Comply with the requirements of BS EN 13480-3.

B. Ensure structure is suitable for the transmitted stress.

C. Provide guides in accordance with the expansion joint manufacturer's requirements. Ensure that movement of pipework is directed from anchor points towards loops and bellows and ensure thrust is along the line of the pipework. Provide a friction reducing material between adjacent metal surfaces subject to movement.

D. The anchor and guide components shall be of suitable size and design to withstand and transfer the pipeline thrust. They shall be constructed to the general requirements of BS 13480.

E. The anchor loads, anchor and guide locations, method of fixing to the structure and design details shall be submitted and reviewed prior to commencement of the works.

F. Where bellows are used the manufacturer's recommendations shall be submitted for review and strictly adhered to.

G. Thrust blocks and suitable anchors shall be provided where pipework internal pressures are not contained by the jointing system.

H. Install guides on each side of axial expansion joints. The first primary guide shall be located within a distance of 4 pipe diameters or 300mm, whichever is the less. The second primary guide shall be located within a distance of 14 pipe diameters from the first guide. Where axial expansion joints are positioned next to an anchor the maximum distance shall be 4 pipe diameters or 300mm, whichever is the less

I. Ferrous piping (Horizontal, non-insulated): Galvanised steel anchor chair and U-bolt attached to structural steel framework.

J. Ferrous piping (Horizontal, insulated): Gusset plates (minimum thickness equal to that of the pipe) welded to pipe and bolted to structural steel frame. Vapour barrier shall be sealed around the gusset plate with mastic sealant.

K. Ferrous piping (Vertical, non-insulated): Steel U-Bolt fixed to steel channel. The bolt shall be back welded to the pipe after installation.

L. Ferrous piping (Vertical, insulated): Same as the support of vertical insulated ferrous piping over DN 150 (6 inch); excluding the vibration isolation pad. The bearing plate shall be welded or bolted down to the cross channel.

M. Copper piping (Horizontal): Galvanised steel anchor chair and U-Bolt over rubber support inserts all round, attached to structural steel frame work.

N. Copper piping (Vertical): Galvanised steel offset riser clamps, over rubber support inserts all round.

O. Plastic piping (Horizontal): Galvanised steel anchor chair and U- bolt attached to structural steel framework.

P. Plastic piping (Vertical): Steel U-Bolt fixed to steel channel.

Copyright © Buro Happold Limited

Q. Anchor / Thrust block
   1. Contractor shall provide suitably designed anchor blocks in cement concrete/steel support to cater to the excess thrust due to water hammer and high pressure
   2. Thrust blocks shall be provided at all bends, tees and such other location as determined by the Employer representative.
   3. Exact location, design, size and mix of the concrete blocks/steel support shall be as shown on the drawings or as directed by the Employer representative prior to execution of work

2.7 HANGER RODS AND ACCESSORIES

A. Galvanised steel hanger rods: Galvanised mild steel rods with continuous male thread.

B. Turnbuckles: Galvanised, malleable iron castings with female threaded ends, matching with the threaded hanger rods, shall be provided where required. Back nuts shall be provided on both sides of the turnbuckle after adjustment.
Reference - ISHRAE Installation guide Type-13

C. Threaded rod couplers: Galvanised steel unit machined from bar stock for joining two lengths of threaded hanger rods. Back nuts shall be provided on both sides of the coupler.
Reference - ISHRAE Installation guide Type-13

2.8 BUILDING ATTACHMENTS

A. Concrete inserts: Malleable iron or galvanised steel concrete inserts complete with adjustable insert nut, suitable for hanger rods of size 22 mm (7/8 inch) diameter and under. Galvanised steel continuous concrete insert shall be provided at the Contractor's option.

B. Self -drilling type concrete inserts: Galvanised steel self drilling expansion type concrete inserts for hanger rods up to 12 mm (½ inch) dia., shall be provided at the Contractor's option.

C. Support rails (cast-in type): Electro-galvanised steel sections with anchor lugs and filler strip, complete with hammer head nut or extension pieces.

D. Support rails (surface mounted type): Electro-galvanised steel sections complete with hammerhead nut or extension pieces. The rail shall be single or double as appropriate.

E. Inserts and Expansion bolts:

   1. Furnish and set inserts in concrete forms.
   2. Concrete inserts shall be as follows: Black malleable iron universal type for threaded connections with lateral adjustment for pipe sizes up to 200mm.
   3. For pipes 200 mm and over or equivalent group of pipes on trapeze, use two or more inserts to prevent exceeding maximum loading.
   4. As an alternative to the above mentioned inserts the Contractor may use expansion bolts. If the Contractor uses expansion bolts, the maximum spacing between supports may need to be reduced so as not to exceed the maximum loading and the expansion bolt locations shall be determined in coordination with the structural elements.

Copyright © Buro Happold Limited

2.9 SUPPORT INSULATORS.

1. The Contractor shall provide moulded hard rubber insulators at all supports of insulated pipework to transmit pipe load to hangers (or supports) without crushing the insulation. The rubber density shall not be less than 1100 kg/m3 and operating temperature range shall be -20 deg C to 110 deg C. The thickness of insulators shall be same as the insulation, and vapor barrier (where specified) shall be continuous across the outside of the insulators.

2.10 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel, G.I hanger rods, nuts, saddles, and U-bolts(Rubber lined). Alternatively comply with BS EN 13480-3 section 13

2.11 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following as per manufacturers list attached with tender documents.

   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with inturned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
   7. Metallic Coating: Electroplated zinc or Hot-dipped galvanized
   8. Paint Coating: Epoxy or Polyester.
   9. Plastic Coating: Polyurethane, Epoxy or Polyester

2.12 THERMAL-HANGER SHIELD INSERTS

A. Provide shields where required, to protect insulation at areas of contact with hangers and supports.

B. Brackets on pipework which is insulated shall have proprietary made heavy density phenolic foam (with zero ODP) circular rings or flat sections, of equal thickness to the insulation, inserted between the bracket and pipe or duct.

C. The inserts shall incorporate a factory applied metal spreader plate and a Class 0 vapor barrier. The length of the insert shall extend outside the bracket by at least 15mm each side.

D. Where pipework expansion takes place on roller chairs, the insert shall extend the full expansion distance plus 15mm and an outer galvanized sheet steel casing of suitable thickness shall be secured to the insert to prevent damage.

E. On pipework systems operating at elevated temperatures the inserts shall be suitable for the operating conditions.

F. Vapor barriers shall be continuous over the inserts and in the case of roller chairs, under the outer galvanized sheet casing.

G. Pipework insert density is to be as follows:

Pipe size (mm)	Density (kg/m³)
Up to 100	80
Over 100	120

H. Inserts for HTHW and steam services shall be constructed from calcium silicate.

Copyright © Buro Happold Limited

I. Insert Length: Extend 50 mm beyond sheet metal shield for piping operating below ambient air temperature.

2.13 FASTENER SYSTEMS

A. Verify suitability of fasteners in this article for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.

B. Supports shall be solidly fixed to the structure using proprietary manufactured drill and plug fixing devices with removable bolt or screw. Wooden plugs, loose fill or masonry nails will not be allowed. Gun fixings will only be allowed when specifically approved.

C. At each support fixing a steel channel or angle iron section shall be secured to the structure from which pipework, ductwork supports and brackets and equipment supports shall be attached.

D. Holes in steelwork supports and brackets shall be formed by correctly drilling, using the recommended tolerances for that which is to be inserted. Flame gun / welding torch holes burned out will not be allowed.

E. Where individual pipes up to 50mm diameter are supported on timber or lightweight walls, ceilings or partitions, brackets shall be of the screw fixing type and primary channel or angle iron brackets shall not be used. On solid / heavy walls over 100mm thickness, individual pipework may be supported by the use of built-in, long shank holder bats or pipe brackets.

F. Supports from the building structural steelwork shall be made using proprietary manufactured steel clamps or girder lugs. Direct drilling of the structural steelwork will not be allowed.

G. Where high level pipework and equipment cannot be supported from the structure, a primary Galvanized steelwork supporting frame shall be provided, fixed to the floor and of suitable design to spread the load evenly, from which all pipework and equipment shall be supported.

H. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

I. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

J. Use largest size of bolt, screw to suit diameter of hole in equipment to be fixed. Ensure that fixings are tested for tensile loading to BS 5080, this particularly applies to expanding anchors.

K. Plastic plugs of suitable size and length shall be used. Use screws to BS 1210. For fixing to concrete, brickwork or block work use sheradized steel wood screws but in damp or exposed situations use greased brass screws.

L. Obtain approval if shot fired fixings are proposed.

2.14 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece GI base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: G.I
3. Vertical Members: Two or more G.I continuous-thread rods.
4. Horizontal Member: G.I rod with plastic or stainless-steel, roller-type pipe support.

Copyright © Buro Happold Limited

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.15 Equipment Support

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

PART 3 - EXECUTION

3.1 HANGERS AND SUPPORT INSTALLATION

A. Pipework support systems shall be supported from the building structure, generally conforming with the following and where specified elsewhere:

- BS EN 13480-3 Metallic Industrial Piping. Design and Calculation
- MSS SP 58, Pipes, hangers and supports- Materials Design and Manufacturer
- MSS SP 69, Pipes, hangers and supports- Selection and Application
- Manufacturer’s recommendations in respect of plastic pipe.
- EJMA Standards for expansion joints
- Uniform Mechanical Code
- Seismic Restraint Manual for Mechanical Systems.

B. Pipework supports are to be arranged so that minimum stress is imposed upon the pipelines or ductwork. Additional supports are required on either side of equipment such as valves, strainers, and the like on pipework. It is important to ensure that all materials used for pipework supports are compatible with the pipeline materials.

C. The details shown elsewhere indicate brackets, and support details which may be acceptable subject to the application but the final working details, drawings or sketches shall be submitted for Review.

D. Rigid coupling may be used with IPS steel piping systems, which meet the support and hanging requirements of ASME B31.1 and ASME B31.9. An adequate number of grooved flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe and column shortening due to creepage & shrinkage.

E. INSERTS

- Inserts shall be provided to relevant Sections for placement in concrete formwork for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- Hooked rod shall be provided in concrete for inserts carrying pipe over DN 150 (6 inch).

Copyright © Buro Happold Limited

- Where concrete slabs form finished ceiling, inserts shall be installed flush with the slab soffit.
- Where inserts are omitted due to error, the slab shall be drilled through from below and through bolt with square steel plate and nut above shall be provided, recessed into and grouted flush with slab.
- Type and quality of expansion type anchors, where used, shall be selected to suit the concrete into which it is to be installed.

F. Hanger or support assembly shall be capable of taking up the filled weight of piping for half spans on either side plus 100 kg, with minimum overall factor of safety of two.

G. Hangers shall be installed with minimum 12 mm (½ inch) space between finished covering and adjacent work.

H. Hanger shall be placed within 300 mm (12 inch) of each horizontal elbow.

I. Hangers shall have a minimum vertical adjustment of 38 mm (1½ inch).

J. Multiple or trapeze hangers shall be provided where several pipes can be installed in parallel and at same elevation.

K. Riser piping shall be supported independently of connected horizontal piping.

L. Piping shall be supported on both sides (at the system side only on connections to equipment) of flexible connections.

M. No support, hanger or anchor shall be attached to the building structural elements wherein their installation, weight or expansion stress will result in damage to the structure.

N. One coat of zinc rich primer shall be applied, after scraping and brushing the area clean, to the weld and surrounding areas, where pipe support members are welded to building structural framing.

O. Piping buried in raft slabs or trenches shall be supported as detailed on the Contract drawings. The support shall be capable of holding the pipe in position against buoyant forces exerted during pouring of concrete.

P. Pipework supports are to be arranged so that no undue stress is imposed upon the pipes.

Q. The installer will be responsible for marking out the exact positions where pipe brackets are to be built in and for checking the accuracy, levels and alignment of supports after building in by others.

R. All vertical pipes shall be fixed by galvanized clamps and galvanized angle brackets truly vertical.

S. Branch pipes shall be connected to the stack at the same angle as that of the fittings. No collars shall be used on vertical stacks.

T. Horizontal pipes running along ceiling shall be fixed on galvanized adjustable type clamps of special design as directed and as required.

U. Horizontal pipes shall be laid to uniform slope and the clamps adjusted to the proper levels so that the pipes fully reset on them.

V. Contractor shall provide all sleeves, openings, hangers, inserts during the construction. He shall provide all necessary information to the building contractor for making such provisions in the structure as necessary. All damages shall be made good to restore the surfaces.

W. All pipes clamps, supports and hangers shall be galvanized. Factory made prefabricated clamps shall be preferred.

X. Contractor may fabricate the clamps of special nature (at the discretion of the clients representative) and galvanize them after fabrication but before installation. All nuts, bolts, washers and other fasteners shall be factory galvanized.

Y. Frames shall be of approved design and fabricated from MS flats (which shall be galvanized after fabrication) of thickness and sizes as per contractor's approved shop drawings.

Copyright © Buro Happold Limited

Z. Clamps shall be fixed in accordance to manufacturer's details/shop drawings to be submitted by the contractors.

AA. When required to be fixed on RCC columns, walls or beam they shall be fixed with approved type of galvanized expansion anchor fasteners (Dash fasteners) of approved design and size according to load.

BB. Structural clamps e.g. trapeze or cluster hangers shall be fabricated by electro-welding from MS structural members e.g. rods, angles, channels flats as per contractors shop drawings shall be galvanized after fabrication. All nuts, bolts and washers shall be galvanized and shall be ready made item from a reputed supplier.

CC. Galvanized slotted angle/channel of approved sizes supports on walls shall be provided wherever shown on approved shop drawings.

DD. Angles/channels shall be fixed to brick walls with bolts embedded in cement concrete blocks and to RCC walls with anchor fasteners mentioned above. The spacing of support bolts on support members fixed horizontally shall not exceed 1 m.

EE. All G.I Brackets should be painted with anti rust coat prior being embedded in concrete at the time of civil work itself.G.I Brackets as shown in approved shop drawings.

FF. Pipework supports shall not exceed the maximum intervals as per manufacturer's recommendation. However the sagging of the installation will not be accepted..

GG. Additional supports shall be provided for equipment such as valves, strainers and ancillaries so that minimum stress is imposed on the pipework and the weight is not taken by the pipework. The support arrangement shall allow safe operation and removal of the component.

HH. All brackets and supports shall allow free movement of the pipes due to expansion and contraction with special regard to prevention of damage to any thermal insulation and vapour barrier. Fixed supports and roller/guide flexible support at appropriate locations to be provided to accommodate pipe movement due to thermal expansion/contraction and column shortening at every floor due to creepage , shrinkage and lateral displacement (wind and earth quake case and building settlement).

II. Where multiple pipe runs of differing bores are supported from a common point, use support spacing of pipe requiring the closest spacing with adequate provision for the unequal movement due to expansion and contraction. Supports shall also be provided at bends where there is a run of pipework 1 metre or more both sides of the bend.

JJ. Cantilever type supports from walls will not be allowed except for single pipes of diameters up to 50 mm.

KK. Obtain approval for all fixings to structural concrete or structural steelwork and loads imposed on the structure. Shot fired fixings shall not be used or any reinforcement drilled through.

LL. Static point loadings transferred to the structure which cannot be accommodated by the structural fixings shall be spread over a larger area by means of additional brackets and/or additional load spreading primary steelwork.

MM. For vertical support spacing check total self-weight and pressure loading against manufacturer's recommendations when using mechanical joints or end load capable flexible couplings. Ensure adequate support when using non-end load capable flexible couplings.

NN. Direct clipping of the pipes, conduits or cables to the wall or the ceiling or any other structural members shall not be allowed.

OO. In case the supports are to be taken from the block work than the contractor shall clearly identify the locations for the solid block or lintels.

PP. In case of dry wall partions only conduits and small pipes (50mm plastic pipes) can be supported from the drywall partion frame (any extra support location shall be clearly defined) . in case of a heavy material purpose built steel frame shall be provided by the MEP trade contractor.

QQ. The area which is crowded for the services installation; MEP contractor shall coordinate among themselves and design the support according to loads which will supported from the same supports.

Copyright © Buro Happold Limited

RR. MEP Contractor is not allowed to cut any support of the drywall partition frame. This shall be coordinated on site with dry wall partition vendors before the start of the work.

SS. All the Suspended equipment and system components support shall be based on the dynamic loading of the equipment and supporting shall be designed accordingly.

3.2 PIPEWORK SUPPORT SPACINGS

A. Provide pipework supports such that the maximum intervals listed below are not exceeded.

B. Table 1 applies to Pressurised Pipework listed below:

- Steel - BS EN 10255, BS EN 10217, BS EN 10216-1
- Schedule 40, Schedule 30
- Copper - BS EN 1057
- Cast Iron - BS 4622
- Ductile Iron - BS EN 545, BS EN 598 and BS EN 969

TABLE 1

Nominal PIPE BORE (mm)	MAXIMUM SUPPORT SPACING (m)					
	STEEL PIPE		COPPER PIPE		IRON PIPE	
	horizontal	vertical	horizontal	vertical	horizontal	vertical
Up to 15	1.8	2.4	1.2	1.8	-	-
20	2.4	3.0	1.4	2.1	-	-
25	2.4	3.0	1.8	2.4	-	-
32	2.7	3.0	2.4	3.0	-	-
40	3.0	3.6	2.4	3.0	-	-
50	3.0	3.6	2.7	3.0	1.8	1.8
65	3.7	4.6	3.0	3.6	-	-
80	3.7	4.6	3.0	3.6	2.7	2.7
100	3.7	4.6	3.0	3.6	2.7	2.7
125	3.7	5.4	3.0	3.6	-	-
150	4.5	5.4	3.6	4.2	3.7	3.7
200	5.0	6.0	-	-	3.7	3.7

Copyright © Buro Happold Limited

250	5.0	6.0	-	-	4.5	5.4
300	6.1	10.0	-	-	8.0	10.0
350	10.0	12.0	-	-	-	-
400	10.5	12.6	-	-	-	-
450	11.0	13.2	-	-	-	-
500	12.0	14.4	-	-	-	-
600 and above	14.0	16.8	-	-	-	-

Note: For refrigeration pipework 15 - 28mm support copper pipework on continuous plastic coated cable tray.

C. Table 2 - Applies to Plastic Pipework listed below:

- Polythene - BS EN 13244
- Polythene - BS EN 12201
- ABS - BS 5391
- PVC-U - BS EN ISO 1452

TABLE 2

PIPE BORE (mm) Nominal	MAXIMUM SUPPORT SPACING (m)			
	UPVC PIPE & ABS PIPE		POLYETHYLENE/PB PIPE	
	Class O,B,C,	Class E, 6,7	BS EN 12201	BS EN 13244
Up to 10	-	0.6	0.3	0.45
15	-	0.6	0.4	0.6
20	-	0.65	0.4	0.6
25	-	0.75	0.4	0.6
32	-	0.8	0.45	0.7
40	-	0.9	0.45	0.7
50	1	1	0.55	0.85
65	1.2	1.2	0.55	0.85
80	1.2	1.2	-	0.9
100	1.3	1.3	-	1.1
125	1.5	1.5	-	-
150	1.6	1.6	-	1.3
175	1.7	1.8	-	-

Copyright © Buro Happold Limited

200	1.9	2	-	-
225	2	2	-	-
250	2	2	-	-
300	2.4	2.4	-	-
350	2.4	2.4	-	-
400	2.4	2.4	-	-
450	2.4	2.4	-	
above 450	2.4	2.4	-	

Note:

Class O	-	*(Non pressure)*	*Class B*	-	*6.0 Bar*
Class C	-	*9.0 Bar*	*Class D*	-	*12.0 Bar*
Class E	-	*18*	*Class 6 & 7*	-	*pressure varies refer to BS*

- For plastic pipework in Table 2 the vertical spacing may be a maximum of 1½ times the horizontal spacing.
- For UPVC and ABS pipework reduce spacing if operating at temperatures above 20°C in accordance with manufacturers requirements for temperature above 60°C provide continuous supports.

D. Table 3 -Applies to Pressure Polypropylene Pipework

TABLE 3

TABLE 3 POLYPROPYLENE TO BS EN ISO 15874-1			
PIPE OUTSIDE DIAMETER mm	MAXIMUM SUPPORT SPACING (m)		
	20°C	60°C	100°C
20	0.6	0.5	0.4
25	0.7	0.6	0.5
32	0.8	0.7	0.6
40	0.9	0.8	0.7
50	1.0	0.9	0.8
63	1.2	1.0	0.9
90	1.3	1.2	1.0
110	1.5	1.3	1.1

Copyright © Buro Happold Limited

E. Table 4 - Applies to Sanitation and Rainwater Pipework listed below

- Iron Piping BS EN 877
- PVC-U Pipes BS EN 1329-1, BS 4514
- Polypropylene BS EN 1451-1
- Vulcathene (Polypropylene)

TABLE 4

PIPE BORE (mm) Nominal	MAXIMUM SUPPORT SPACING (m)					
	UPVC & Polypropylene		Vulcathene		Iron Piping	
	horizontal	vertical	horizontal	vertical	horizontal	vertical
20	-	-	-	-	-	-
25	-	-	-	-	-	-
32	0.5	1.2	-	-	-	-
40	0.5	1.2	1.2	1.5	-	-
50	0.9	1.2	1.4	1.5	1.5	3.0
63	-	-	-	-	-	-
80	0.9	2.0	1.5	1.5	1.5	3.0
100	1.0	2.0	1.8	1.5	1.5	3.0
125	-	-	-	-	1.5	3.0
150	1.0	2.0	1.8	1.5	1.5	3.0
175	-	-	-	-	-	-
200	-	-	-	-	1.5	3.0

Copyright © Buro Happold Limited

3.3 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Support Adjustment: Piping and equipment shall be brought to the proper level by providing grout under the supports.

C. Trim excess length of continuous-thread hanger and support rods to 15 mm.

3.4 CLEANING AND PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.

B. Apply paint by brush or spray to provide a minimum dry film thickness of 0.05 mm.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair (Zinc rich) paint to comply with ASTM A 780.

3.5 HANGERS & SUPPORTS FOR ELECTRICAL SYSTEM :

A. SCOPE :

The specifications given below relates to the testing & supplying support system for busducts, busbars, conduits, cable trays, cable ladders in schedule of quantities at Site:

The scope of work shall include Transporting, loading / unloading the hanger & support system to project site, storing, handling, shifting, installing, testing and commissioning for all the items reflecting in Bill of Quantities & layouts,

B. SUPPORT, ANCHORAGE & ATTACHEMENT COMPONENTS :

1. **Steel Slotted Support Systems:** Factory-fabricated components for field assembly.
   a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to IS Standards.
   b. Non-metallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied.
   c. Painted Coatings: Manufacturer's standard painted coating applied.
   d. Channel Dimensions: Selected for applicable load criteria.
2. **Non-metallic Slotted Support Systems**: Structural-grade, factory-formed, glass-fibre-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches.
3. **Fittings and Accessories:** Products of channel and angle manufacturer and designed for use with those items.
4. **Rated Strength:** Selected to suit applicable load criteria.
5. **Conduit and Cable Support Devices:** Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
6. **Support for Conductors in Vertical Conduit:** Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armoured electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported.
7. **Structural Steel for Fabricated Supports and Restraints:** ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

Copyright © Buro Happold Limited

8. **Mounting, Anchoring, and Attachment Components**: Items for fastening electrical items or their supports to building surfaces include the following:

   a. **Powder-Actuated Fasteners:** Threaded-steel stud, for use in hardened cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   b. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      - Hilti Inc.

   c. **Mechanical-Expansion Anchors:** Insert-wedge-type, stainless steel, for use in hardened cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   d. **Concrete Inserts:** Steel or malleable-iron, slotted support system units similar to MSS Type 18

   e. **Through Bolts:** Structural type, hex head, and high strength. Comply with ASTM A 325.

   f. Toggle Bolts: All-steel springhead type.

   g. Hanger Rods: Threaded steel

C. APPLICATION :

1. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NEC 2011 and relevant IS codes. Minimum rod size shall be 1/4 inch in diameter. Supports shall be selected based on loading as per manufacturers recommendation. Support for busduct including sway movement, seismic and expansion joint.
2. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
3. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2inchand smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

D. SUPPORT INSTALLATION :

1. Raceway Support Methods: In addition to methods described in relevant IS / NBC codes supports may be supported by openings through structure members (any such proposal must be first submitted by the Contractor as a technical submittal for approved by the project Structural engineer.
2. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs (91 KG).
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

   a. To Wood: Fasten with lag screws or through bolts.

   b. To New Concrete: Bolt to concrete inserts.

   c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

   d. To Existing Concrete: Expansion anchor fasteners.

   e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

Copyright © Buro Happold Limited

f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

g. To Light Steel: Machine screws.

h. To GI steel: GI screws shall be permitted.

i. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

j. To Light Steel: Sheet metal screws.

k. Items Mounted on Hollow Walls and Non-structural Building Surfaces: Mount cabinets, panel boards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

l. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. INSTALLATION OF FABRICATED METAL SUPPORTS :

1. Comply with installation requirements for site-fabricated metal supports.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
3. Field Welding: Comply with AWS D1.1/D1.1M.

F. CONCRETE BASES :

1. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
2. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
3. Anchor equipment to concrete base.
   a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   b. Install anchor bolts to elevations required for proper attachment to supported equipment.
   c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

G. PAINTING :

1. **Touch up:** Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.
2. **Galvanized Surfaces:** Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
VOLUME 02	B.2	NOISE, VIBRATION AND SEISMIC CONTROL		
		1.1	GENERAL	1
		1.2	QUALITY ASSURANCE	2
		1.3	SUBMITTALS	2
		1.4	VIBRATION CONTROL	2
		1.5	INSTALLATION AND TESTING	7

Copyright © Buro Happold Limited

1.1 GENERAL

A. This section relates to the prevention of unwanted vibration transmission from mechanical and electrical items of equipment to sensitive areas inside and outside the building.

B. Fabricate, assemble, deliver to site and install vibration control measures to meet the performance standards specified.

C. All intermediate mechanical plant room shall have necessary vibration isolation in supporting system as well as in installation.

D. In seismic control areas provide anti vibration mountings suitable for the zonal classification of the area

E. Note the requirement to reselect vibration control equipment to suit the final actual operating weights and speed of operation of plant.

F. The Contractor shall refer and comply with all the applicable requirements indicated in acoustic consultant's reports/ recommendations.

G. The Contractor shall be responsible for ensuring that the acoustic performance of the equipments meets the design criterion described in the relevant sections of the project specification at the date of equipment procurement.

H. The Contractor shall furnish the complete acoustic report of the equipment prior to start of the procurement procedure.

I. Provide flexible connections to all pump suction and Discharge connection, Air cooled chillers & OAHU's. For detail product specification

J. Provide Rubber mounts for indoor DX and VRF Condensing units.

K. Following Noise criteria table to be followed:

S.NO	LOCATION	NOISE LEVEL
1	Parking	NC-60+
2	Plant room	NC 55-65
3	Retail	NC-45
4	Offices	NC-35
5	Business center	NC-35
6	Multipurpose room	NC-35
7	Spaces within 3m of shaft take offs	NC-40
8	Bathrooms	NC-45
9	Corridors	NC-45
	RESIDENCES:	
1	Nightime: AC unit low speed	NC-30
2	Daytime: AC unit medium speed	NC-35
	AMENITIES:	
1	Tenant gym	NC-40
2	SPA	NC-35/40

Copyright © Buro Happold Limited

1.2 QUALITY ASSURANCE

A. Ensure that the design, construction, materials and finishes of all equipment are suitable for the location, climatic and operating conditions to which the installation will be exposed.

B. Ensure that the whole installation complies with the relevant standards, including the following:

- BS 4800 - Schedule of paint colours for building purposes
- BS 6472-1 - Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting
- BS 4718- Methods of tests of silencers for air distribution system
- ASHRAE equipment and system Handbook-2008
- BS EN ISO 9001- Quality management system requirements.
- IS 1893 -Criteria for Earthquake resistant design of structures.
- SMACNA DW144
- ASTM-E477- Standard test method for Measuring acoustical and airflow performance of duct liner materials and prefabricated silencers.
- ISO-7235- Guide to evaluation of human exposure to vibration in buildings, vibration sources other than blasting
- ISO 5135- Determination of sound power levels of noise from air terminal devices.
- AMCA 300 & 301- Reverbant room method for Sound testing of fans/Methods for calculating ban sound ratings from LAB test data.
- NEBB- National Environmental Balancing bureau.
- CIBSE B5- Noise and Vibration control for HVAC.

1.3 SUBMITTALS

A. Provide a fully documented set of the calculations upon which the vibration equipment has been selected.

B. Contractor shall submit the typical details of equipments with the vibration isolations details as per acoustic consultant's requirement.

1.4 VIBRATION CONTROL

A. Vibration Isolators - General

1. Supply and install vibration isolators as indicated on the vibration isolation schedules and also wherever necessary to limit vibration transmission into the building structure, supporting structure, pipework or ductwork, Chiller , Pump's, AHU's, Fan's, Transformer's, DG sets , FCU's , Indoor AC units, VRF/VRV equipment's etc.
2. Ensure that any vibration transmitted from the mechanical and electrical services installations into the building structure does not exceed the 83dba at 1.5m distance.
3. Ensure that the maximum vibration amplitudes specified in BS 6472-1 or ASHRAE guidelines are not exceeded.
4. Select vibration isolators so that they are suitable for the loading, operating and environmental conditions which will prevail. Pay special attention to vibration isolators exposed to atmospheric or adverse interior conditions and apply appropriate finishes to prevent corrosion.
5. The static deflection of vibration isolators shall be selected to give the necessary degree of isolation efficiency under the lowest normal operating speed of the isolated plant. Selection shall allow for asymmetric load distribution such that the minimum static deflection is achieved on all vibration isolators under normal operating conditions. All machines and bases shall be carefully levelled. Replace any vibration isolators which are "bottomed out" or where the springs have deformed from a cylindrical shape at no extra cost to the contract.
6. All vibration isolators shall be colour coded or otherwise clearly marked to indicate rated load and deflection capacity to facilitate identification during installation.

Copyright © Buro Happold Limited

7. All external connections to vibration isolated plant shall be made using flexible connections. Particular care shall be taken to ensure that the connection of pipes, ducts, shafts, electrical conduit etc., to vibration isolated plant neither short circuits the plant vibration isolation, nor impedes the free movement of the vibration isolated plant.
8. The vibration isolation system shall be selected to support the operating weight of the plant and equipment to be isolated only. All associated pipework, valves, filters, ductwork etc., and their contents shall be supported independently so as not to impose additional forces on the isolator system. All flexible connections shall be selected and arranged to accommodate this requirement.
9. All plant, pipework and ductwork shall be resiliently isolated from any part of the building structure as specified, or as otherwise required, to achieve the specified noise and vibration criteria. Particular attention shall be paid to areas where low noise levels are specified. The mounting of any item of plant, pipework (bigger than 50mm plastic pipes) or ductwork from lightweight (stud) partitions is not permitted.
10. Select spring mounts with an overload capacity of 50% and with an outside diameter of at least 75% of the operating height. Mark mounts permanently with load capacity.

B. Vibration Isolation Plant and Equipment

1. Unless otherwise stated, plant and equipment isolators shall be provided as indicated on the following schedules. For specification of isolator types refer to the following clauses. Isolators must be selected for the operating weight of equipment and shall be positioned for equal deflection.
2. Unhoused Spring Mounts (Type S)

   Provide where indicated on the vibration isolation schedule unhoused spring mounts. The mountings shall comprise of free standing, unhoused, laterally stable steel spring with a top and bottom load plate and leveling bolt.
3. Vertically Restrained Spring Mounts (Type L)

   Provide where indicated on the vibration isolation schedule vertically restrained spring mounts. The mountings shall comprise high strength; low stress helical steel and springs capped with steel pressure plate on neoprene base pad. Supply base plate pre-frilled for bolting down and painted for protection. Supply unit complete with lockable leveling device to limit the vertical movement.
4. Pre-Compressed Moulded Glass Fibre Mounts (Type F)

   Provide where indicated on the vibration isolation schedule pre-compressed moulded glass fibre mounts. The mountings shall be composed of inert inorganic material covered with an elastomeric coating to increase damping and protect the glass fibres. The isolation pad shall be bonded to a steel load transfer washer and formed steel bolt down bracket and shall include a steel bolt with a neoprene grommet.
5. Spring Compression Hangers (Type H)

   Provide where indicated on the vibration isolation schedule spring hanger mountings. In addition spring hangers shall be used to support all pipework and ductwork connected to rotating and reciprocating machinery within plantroom areas or within 15 m of the plant which ever is the lesser.

   When used for supporting pipework and ductwork the springs shall have a minimum deflection of 25mm unless otherwise stated.

   The hangers shall comprise of a steel spring or glass fibre pad or a combination of both retained in a welded steel bracket. The steel spring shall be free standing, unhoused and laterally stable having horizontal spring stiffness equal to or greater than 1.3 times the vertical stiffness. The hanger bracket shall be designed to carry five times overload without failure and shall allow up to 15mm dia rod misalignment without metal to metal contact.
6. Kinetic Neoprene Mounts (Type N)

Copyright © Buro Happold Limited

Provide where indicated on the vibration isolation schedule Kinetic neoprene isolators. The moulded neoprene isolators shall be complete with a cast in tapped steel load plate to permit bolting to supported equipment and a cast in steel anchor base plate pre-drilled for holding down bolts. The neoprene shall be oil and corrosion resistant.

7. Inertia Bases (Type S-I)
   Provide where indicated on the vibration isolation schedule inertia bases manufactured from welded steel channels designed to receive concrete poured into the steel frame. The steel frame shall incorporate pre-located equipment anchor bolts and free-standing laterally stable spring mounts generally as described under type S mounts.

8. Inertia Bases (Type L-I)

   Provide where indicated on the vibration isolation schedule inertia bases generally as type S-I except that the springs shall be type L vertically restrained.

9. Inertia Bases (Type F-I)

   Provide where indicated on the vibration isolation schedule inertia bases generally to type S-I except that the isolators shall be moulded glass fibre isolators as described under type F mounts.

10. Steel Base Frames (Type S-B)

    Provide where indicated on the vibration isolation schedule steel frame bases manufactured from structural steel members incorporating isolator mounting brackets and supported by free standing spring isolators as described under type S mounts.

11. Steel Base Frames (Type L-B)

    Provide where indicated on the vibration isolation schedule steel beam bases manufactured from structural steel members incorporating isolator mounting brackets and supported by vertically restrained spring isolators as described under type L mounts.

C. FLEXIBLE CONNECTIONS-GENERAL

1. Flexible connections shall be fitted to all Pump Suction and Discharge connections, Chillers Condensers and other centrifugal reciprocating or vibrating equipment where it is marked on the drawing, and where anti-vibration mounts, inertia bases are fitted.
2. Flexible Connections must have been tested for Noise and Vibration reduction capabilities, with due Certification being submitted to the Engineer for approval prior to the order being placed.
3. Flexible Connections are to be fitted as close to the source of vibration as practicable. The pipe at the other end of the Flexible Connection is to be a fixed point. This is necessary to reduce the noise, vibration and resonances from the distribution pipework to the building fabric, and prevent any stresses in the pipework from being transmitted upon the pump or vibrating equipment. To ensure correct alignment, a spool piece is to be employed during installation.
4. Rubber Flexible Connections shall be single convolution of hand laid multi ply reinforced EPDM rubber with wire reinforced cuffs. Flanges shall be removable and suitably profiled to control the convolution shape; plate flanges must not be used.
5. To avoid over tightening and damaging the sealing face of the rubber bellows the flanges shall be designed to make metal to metal contact with its mating flange when fully tightened.
6. Threaded and adjustable tie bars with rubber top hat washers shall be used where the working pressure exceeds 1.5 bar g. When untied Flexibles are used, the manufacturer's recommendations for anchors and guides shall be followed to prevent forces being exerted on to the pump casing and AV mounts.
7. All flexible connections shall be compliant with the PED (Pressure Equipment Directive) and be stamped with the CE mark.

D. RUBBER TYPE FLEXIBLE CONNECTORS HIGH TENSILE SYNTHETIC FIBRE REINFORCED TYPE FOR TEMPERATURES UP TO 70°C

Copyright © Buro Happold Limited

1. For working temperatures up to 70°C the bellows carcass shall be reinforced using high tensile synthetic fibre.
2. Manufacturer: 1) Engineering Appliances Limited, 2) Kinetics 3) Resistoflex 4) systemflex or similar approved.

E. RUBBER TYPE FLEXIBLE CONNECTORS STEEL WIRED REINFORCED TYPE FOR TEMPERATURES 70-100°C

1. For working temperatures between 70°C and 100°C the Flexible carcass must be steel wire mesh reinforced throughout to prevent catastrophic failure, as nylon reinforcements do not provide the system security and safety required at these temperatures. The Rubber Flexible Connections are to have a minimum design life of 10 years, continuously operating at 100°C and then have a minimum burst pressure of 30 bar g, in compliance with the minimum requirements of DIN 4809-1. An up to date and valid compliant certificate must be provided. The approval number shall be vulcanized into the rubber and coincide with that shown on the certificate.
2. The flexible bellows shall be fully traceable: and moulded into the carcass shall be the manufacturer, country of origin, type and batch number, serial number, and the date of manufacture.
3. Manufacturer: Engineering Appliances Limited STENFLEX type AS EA53, EA51-untied/EA58, EA52 -tied. (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

F. STAINLESS STEEL TYPE FLEXIBLE CONNECTORS FOR TEMPERATURES ABOVE 100°C

1. For temperatures above 100°C Flexible Connection must not be manufactured from Rubber, but shall be of stainless steel thick wall spirally wound multi-ply construction to provide the required noise and vibration reduction. The flexible shall be 130mm long and provided with Van Stone ends and swivel flanges. This type of Flexible Connection being for installations where the pump is on “solid” AV mounts
2. Manufacturer :(1) Engineering Appliances Limited type Epsilon EA46/49 (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

G. FLEXIBLE CONNECTORS FOR USE WITH EQUIPMENT ON SPRING TYPE SUPPORTS

1. For installations where the pump and/or pipe work is on spring type supports, the flexible shall be as indicated above(rubber of stainless steel), but shall be a lateral type unit with a double membrane to give greater flexibility for this type of installation.
2. Manufacturer: (1) Engineering Appliances Limited type EA23 (2) Kinetics (3) Resistoflex (4) Systemflex or similar approved.

H. FLEXIBLE HOSES

1. Provide where indicated on the drawings or as required. Rubber type has limited life and temperature. Rubber type not suitable for potable water services. Stainless steel type not suitable for elevated chlorine levels in excess of 200ppm.
2. Rubber type: Comprise unreinforced 3mm thick EPDM rubber liner with a stainless steel braid. Fittings are swaged using AISI 304 stainless steel ferrules suitable for design temperatures -10°C to 100°C. Manufacturer: 1) Engineering Appliances Limited (2) Kinetics (3) Resistoflex (4) systemflex or similar approved.
3. Stainless Steel type: Comprise longitudinally welded thin wall stainless steel (AISI 321) convoluted tube with stainless steel (AISI 304) braid. Fittings to suit pipework size and material. Suitable for temperatures 100 – 130°C. Manufacturer: Engineering Appliances Type EA71 & EA 73 (2)Kinetics (3) Resistoflex (4) systemflex or similar approved.

I. Vibration Isolation Schedule

Equipment	Equipment location

Copyright © Buro Happold Limited

type	Basement		Ground or up to 6m floor span		9m floor span		12m floor span		15m floor span	
	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)
Refrigeration machines										
Air or refrigeration compressors up to 750 rpm	S	25	S-B	38	S-I	62	S-I	62	S-I	69
Air or refrigeration compressors over 750 rpm	S	25	S	25	S-I	38	S-I	62	S-I	69
Pumps										
Close coupled up to 7.5 kW	N *	9	N	9	S-B	25	S-B	25	S-B	25
Close coupled over 7.5 kW	S-I *	19	S-I	25	S-I	38	S-I	62	S-I	62
Base mounted and belt driven up to 7.5 kW	F-I *	9	F-I	9	S-I	38	S-I	44	S-I	62
Base mounted and belt driven over 7.5 kW	S-I *	25	S-I	25	S-I	44	S-I	62	S-I	88
Generators Engines										
up to 18 kW	F-I	9	F-I	9	S-I	44	S-I	62	S-I	62
19-99 kW	F-I	9	S-I	44	S-I	62	S-I	88	S-I	88
100 kW and over	S-I	25	S-I	62	S-I	88	S-I	127	S-I	127
Axial Fan and Low Pressure Centrifugal Fans (Up To 75mm) and Air Handling Units										
Suspended units (up to 4 kW)	H	19	H	25	H	25	H	25	H	25
Suspended units over 4 kW up to 500 rpm	H	32	H	32	H	32	H	44	H	62
Suspended units over 4 kW and over 500 rpm	H	25	H	25	H	25	H	32	H	44
Floor mounted units (up to	N	9	S	25	S	25	S	25	S	25

Copyright © Buro Happold Limited

Equipment type	Equipment location									
	Basement		Ground or up to 6m floor span		9m floor span		12m floor span		15m floor span	
	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)	Isolator type	Static deflection (mm)
4kW)										
Floor mounted units over 4 kW (up to 500 rpm)	N	9	S-B	44	S-B	44	S-B	44	S-B	62
Floor mounted units over 4 kW (over 500 rpm)	N	9	S	25	S	25	S-B	38	S-B	44
High Pressure Centrifugal Fans (Over 750 N/m²) and Air Handling Unit(Floor Mounted)										
up to 15 kW (up to 300 rpm)	N	9	S-B	62	S-B	62	S-B	88	S-B	127
up to 15 kW (301-500 rpm)	N	9	S-B	44	S-B	44	S-B	62	S-B	88
up to 15 kW (501 rpm and up)	N	9	S-B	25	S-B	25	S-B	44	S-B	62
over 15 kW (up to 300 rpm)	N	9	S-B	62	S-I	88	S-I	127	S-I	140
over 15 kW (301-500 rpm)	N	9	S-B	44	S-I	62	S-I	88	S-I	127
over 15 kW (501 rpm and up)	N	9	S-B	25	S-I	44	S-I	62	S-I	88

*** NOTE: For Fire Protection Pumps, there will no Inertia bases and pumps will be mounted on PCC blocks with anti vibration rubber mounts.**

1.5 INSTALLATION & TESTING

A. Provide installation and testing of complete ductwork systems.

B. Carry out commissioning tests in accordance with this specification.

C. Demonstrate at commissioning stage, to the satisfaction of the Clients representative, that all specified vibration levels have been achieved.

D. When installing anti-vibration mountings comply with manufacturer's instructions.

E. Level equipment to ensure loads are evenly distributed.

F. Protect all equipment from damage by ingress of water or dirt.

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE No.
Volume 02	B.3	EXPANSION FITTINGS AND LOOPS		
		PART 1 - GENERAL		
		1.1	SUMMARY	1
		1.2	PERFORMANCE REQUIREMENTS	1
		1.3	SUBMITTALS	2
		1.4	QUALITY ASSURANCE	2
		PART 2 - PRODUCTS		
		2.1	EXPANSION SYSTEMS	3
		2.2	EXPANSION LOOPS GENERAL	3
		2.3	EXPANSION LOOPS - STEEL	3
		2.4	MECHANICAL EXPANSION JOINTS	3
		2.5	UNRESTRAINED EXPANSION JOINTS	4
		2.6	RESTRAINED EXPANSION JOINTS	4
		2.7	PIPELINE ANCHORS AND GUIDES	4
		2.8	SERVICES CROSSING BUILDING EXPANSION JOINTS	4
		2.9	FLEXIBLE CONNECTIONS DETAILS	5
		PART 3 - EXECUTION		
		3.1	EXPANSION-JOINT INSTALLATION	5
		3.2	INSTALLATION	7

Copyright © Buro Happold Limited

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Expansion Loops.
2. Mechanical Expansion Joints
3. Unrestrained Expansion Joints.
4. Restrained Expansion Joints.
5. Alignment guides and anchors.
6. Flexible Connections

1.2 PERFORMANCE REQUIREMENTS

A. Responsibility of Contractor:

1. Determine required system expansion, compensation, and location of all guides anchors and expansion devices using finalized contractor's installation drawings.
2. Design and provide expansion compensation devices, equipment and anchors.
3. Provide calculations by a licensed professional engineer substantiating that expansion compensation is designed to meet all system expansion requirements and safely accept generated forces without failure.
4. Coordinate expansion requirements with the work of other trades.
5. Provide structural engineer with required loads and forces required to support and restrain piping. Approval of these loads is required prior to pipework installation commencing.

B. Provide sufficient supports, fixing and pipework components in such a manner that expansion and contraction of the pipework is fully accommodated.

C. Generally movement shall be accommodated at all changes in direction and/or at terminations of pipework.

D. Branch connections or pipe junctions to main pipework shall be made with 2 Nr 90° changes in direction to form an offset of suitable length to facilitate the expansion/contraction and prevent excess strains on the pipework joints at the junctions.

E. Where expansion or contraction of pipework cannot be accommodated as described above expansion loops or mechanical expansion joints shall be provided.

F. The application, location and type of joints shall be in accordance with BS 6129-1.

G. Where expansion devices are installed the correct amount of "cold draw" must be applied and adequate provision shall be made for temporary clamps or spacer pieces during the testing operations defined elsewhere.

H. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures. Mechanical expansion devices and flexible connections used on water services piping shall be WRAS approved, or similarly approved for potable water systems by the local municipality.

I. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

J. Provide & Comply to lateral displacement (wind case & earthquake case) building settlement and column shortening (due to creepage and shrinkage) requirements specified in section B.1-clause E & F.

Copyright © Buro Happold Limited

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of expansion joint, from manufacturer.

E. Maintenance Data: For expansion joints to include in maintenance manuals.

F. Expansion joints calculation for vertical risers: Furnish movement calculation based on the following criteria:

1. Minimum creepage and shrinkage factor of 3mm per floor.
2. Thermal expansion and contraction
3. Lateral displacement(wind & earthquake case) & building settlement as specified in section B.1-clasue E & F

1.4 QUALITY ASSURANCE

A. Comply with the following:

- BS 13480-3 - Metallic industrial piping. Design and calculation
- BS 6129-1 - Code of practice for the selection and application of bellows expansion joints for use in pressure systems. Metallic bellows expansion joints
- EJMA "Standards of the Expansion Joint Manufacturers Association"

Copyright © Buro Happold Limited

PART 2 - PRODUCTS

2.1 EXPANSION SYSTEMS

A. Where possible provision for movement due to thermal expansion and contraction shall be made by natural changes in the direction of pipework. Provide expansion loops or mechanical joints if necessary.

B. Anchors and guides shall be positioned to contain all movement and resist the maximum loads imposed.

C. Anchors and guides are to be located at points which prevent excess stresses on pipework, joints and equipment connections.

D. Similar provisions shall be made for building movement or building settlement.

2.2 EXPANSION LOOPS GENERAL

A. Prefabricated expansion loops shall be constructed in the same pipework class and finish as the pipework system.

B. Where access is limited prefabricated expansion loops shall be used and only on pipework up to 65 mm.

2.3 EXPANSION LOOPS - STEEL

A. Provide expansion loop in the material and finish of the associated pipeline. The loop shall be sized to limit the total stress set up in the material of the pipe wall to less than 69 MPa. The Contractor shall supply calculations for approval by the engineer.

B. Bends shall be from a single length of pipe or by welding fittings if expansion loops are too large to manufacturer in the piece.

C. Drawings indicating the method of anchoring and guides shall be supplied to the engineer for approval.

D. The spacing of the supports shall not exceed the centres given in the pipework section. Where there are two or more pipes the spacings shall be based in the centres required by the smallest bore pipework.

E. Vertical rising pipework shall be supported at the base or, as required to withstand the total weight of the riser and thrust.

2.4 MECHANICAL EXPANSION JOINTS

A. Where natural flexing of the pipework is not practical thermal expansion and building movement shall be accommodated by the use of expansion joints.

B. Expansion joints may be of the restrained or unrestrained type and shall be provided with welded, screwed or flanged ends as appropriate.

C. Expansion joint convolutions shall be of a thick wall spirally wound, multi-ply construction with a corrosion resistant inner ply in AISI 316L stainless steel. Units should be fitted with stainless steel inner sleeves, in compliance with EMJA.

D. For critical services such as MTHW, HTHW and steam, the bellows must have a weep hole as a fail-safe device.

E. Expansion joints shall be capable of not less than 5000 complete reversals of movement at the given working conditions and the manufacturer shall be able to produce calculations to that effect, in full compliance with EJMA (Expansion Joint Manufacturers Association).

F. Expansion joints shall be capable of withstanding a test pressure 1.5 times the design working pressure without deformation. .

Copyright © Buro Happold Limited

G. Expansion joints and their corresponding anchors and guides shall be indicated on the shop drawings and shall be installed strictly in accordance with the manufacturer's instructions and guidelines.

H. All mechanical expansion joints shall be in accordance with BS 6129-1 or EJMA Standards by the expansion joints. They shall be provided with flanged or screwed ends to BS EN 1092-1 and BS EN 10226-1 or ANSI B16.3 and ANSI B16.1, respectively, as appropriate. They shall be manufactured from stainless steel appropriate to the working pressures of the various systems. They shall be supplied with external protective sleeves.

I. Grooved flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe and column shortening due to creepage & shrinkage.

J. The manufacturer's requirements shall be complied with and anchor loads shall be calculated and their proposed locations approved prior to commencement of the works. Where axial bellows are installed the manufacturer shall visit the site and inspect the final installation prior to cold pressure testing.

K. Lateral expansion joints are sometimes also called articulated or fully articulated. Angular expansion joints are sometimes referred to as hinged. For larger lateral movements in two planes two gimbal expansion joints may be used instead of the lateral unit. Restrained expansion joints are not designed to support associated pipework.

2.5 UNRESTRAINED EXPANSION JOINTS

A. Axial expansion joints shall only be used in positions where pressure thrust can be contained by adequate anchor points contained by the building fabric. Recommended guide spacings and tolerances as described in Engineering Appliances "Guide to the use of Expansion joints" are critical and must be strictly adhered to.

B. Axial expansion joints shall be as manufactured by Engineering Appliances Limited their type EA01, EA02EA04, EA06, EA07, EA08, EA15 and EA16 or equivalent approved.

C. Axial expansion joints are not restrained and will exert a pressure thrust. This load can be very high and needs to be contained by suitable anchors. Comply with BS 13480.

2.6 RESTRAINED EXPANSION JOINTS

A. Restrained expansion joints shall be used as an offset type either by using lateral or angular expansion joints to compensate for thermal expansion or building movement. The expansion joint restraints shall be designed to absorb the full pressure thrust of the expansion joint convolutions.

B. Lateral expansion joints shall be of the thick wall spirally wound multi-ply construction and fitted with threaded tie bars and low friction self-lubricating hemispherical nuts, allowing movement in two planes. Lateral expansion joints shall be as manufactured by Engineering Appliances Limited their type EA20, EA23 and EA24 or Equivalent approved.

C. Angular expansion joints shall be of the thick wall spirally wound multi-ply construction and be used in pairs or threes. All hinge pins shall be PTFE coated to reduce friction and prevent corrosion. Angular expansion joints shall be as manufactured by Engineering Appliances Limited their type EA31 and EA32 or Equivalent approved.

D. For movement in two planes Gimbal Expansion joints shall be used in pairs or in combination with one Angular Expansion joint. All hinge pins shall be PTFE coated to reduce friction and prevent corrosion. Gimbal expansion joints shall be as manufactured by Engineering Appliances Limited their type EA38 or Equivalent approved.

2.7 PIPELINE ANCHORS AND GUIDES

Refer section B.1- 2.9 for Pipeline anchors and guides.

2.8 SERVICES CROSSING BUILDING EXPANSION JOINTS

A. At points where services cross the building expansion joints flexible connections, compensators, or expansion joints shall be provided to accommodate the building movement within the services installation.

Copyright © Buro Happold Limited

B. Brackets and supports each side of the flexible joint shall be so arranged that services crossing the building expansion joint remain symmetrical and correctly aligned.

2.9 **FLEXIBLE CONNECTIONS**

Refer Section B.2- 1.4(12) for details.

EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install pipework so that stress is kept below the maximum permissible design stress as given in the appropriate pipework standard.

B. Prior to installation, submit to the consultant for approval the exact locations and working drawing details including magnitude and direction of thrusts of all expansion joints, guides, anchors and other associated equipment.

C. Connect to items of plant and equipment in such a way that no stress is placed on the equipment or its connections.

D. Do not use branch connections as anchor points.

E. Wherever possible, cater for expansion and contraction by the inherent natural flexibility of the service pipework. Where the use of inherent natural flexibility is not practicable, supply, install and connect expansion joints into the pipework installation.

F. Install expansion joints in full accordance with the manufacturer's recommendations and instructions.

G. Prior to commencement of the installation, the contractor must agree with the expansion joint manufacturer to visit site to ensure his guidelines for selection and installation are adhered to. And that the anchors and guides are correctly positioned to ensure that the expansion joints function as intended. During system installation and just prior to application of heat onto the systems, the expansion joint manufacturer is to visit site to check that the installation is installed as designed and a Certificate of Compliance issued.

H. Install expansion joints with a cold pull (cold draw) equal to 50% of total expansion, except where expansion joints are supplied with cold pull already applied. Apply cold pull (cold draw) by means of flanges secured to the ends of pipe to be pulled together with long high tensile steel bolts and nuts. A check with the design figure for correct gap plus allowance for gasket thickness shall be made before final pull is made. A change to standard bolting shall be made when the gap is closed. Do not apply cold pull (cold draw) until the anchor installations have been completed and approved by the Consultant / PM.

I. Install guides on each side of axial expansion joints. The first primary guide shall be located within a distance of 4 pipe diameters or 300mm, whichever is the less. The second primary guide shall be located within a distance of 14 pipe diameters from the first guide. Where axial expansion joints are positioned next to an anchor the maximum distance shall be 4 pipe diameters or 300mm, whichever is the less.

J. Provide intermediate guides for the remainder of the pipework at appropriate intervals.

K. Ensure that guides are capable of withstanding a lateral force of at least 15% of the anchor force.

L. Ensure that the lateral movement of the pipeline permitted by the guide is no more than 2mm (±1mm) for pipes up to 100mm nominal size and 4mm (±2mm) for larger pipes, for the two primary guides next to the expansion joint. For intermediate guides the movement should be no more than 4mm (±2mm) and 8mm (±4mm) respectively.

M. Where pipework up to 50mm size is fixed to solid walls, brackets may be of either the screw fixing type or long shank built-in type. For fixing to woodwork and lightweight partitions or walls, brackets shall be screw-on pattern and may be adjustable two-piece type.

N. Brackets for mild steel pipework shall be mild steel or malleable iron. Brackets for copper pipework shall be brass or gunmetal.

Copyright © Buro Happold Limited

O. Obtain approval from the Consultant/Project Manager for any fixings to structural concrete or structural steel work.

P. Fixings to the building structural element shall generally be by “Redheads”, rawl bolts clamps adaptors or similar approved heavy fixings and white metal rawl plugs or approved plastic type plugs for light loads. Drilling of structural steelwork shall not be used for pipe supports. Supports with backplate in floor screed shall not be used.

Q. Pipework shall be securely supported, singly or in groups, graded to levels required for venting and draining and having regard to the requirements for differential expansion, anchors and guides and thermal insulation sizing.

R. Pipework exposed to view shall have approved brackets or clips of neat appearance, screw fixed to the wall at intervals to give uniform spacings and neat appearance.

S. Non-ferrous clips and rollers shall be used on copper pipes or if steel clips are used lead packing sleeves shall be fitted between pipe and clip.

T. Mains in ducts shall be supported on rollers and chairs using fabricated mild steel brackets (painted) or galvanized channel sections with allowance for building-in or bolting-on to the surface of the duct wall.

U. Pipes at ceiling level or in roof spaces shall be suspended from rods or straps using adjustable mild steel hangers with swinging joints or purpose-made angle iron cradles or other steel sections. Clips shall be used on cold pipes with rollers and chairs on hot pipes and where expansion cannot be readily taken upon hanging brackets.

V. Exposed external steel brackets shall be fabricated then hot dipped galvanized before erection, unless otherwise specified.

W. Allowance for the fitting of pipe covering protection saddles specified shall be made at the support positions on mains that require continuous unbroken weatherproof or vapor proof seal finish, as in the case of chilled water or cold water pipes. Where required, fit load-bearing insulation at supports at the time of erecting this pipework.

X. Pipework of 65mm size and larger subjected to expansion and contraction and hung from supports shall be suspended on swivel hangers unless otherwise agreed with the client.

Y. Hangers for horizontal pipework at high level shall be supported from mild steel angle or channel sections or approved proprietary devices, suitable for building-in or otherwise securing to the structure. Adjustable mild steel hangers shall be used. Drop rods shall not be less than 13mm diameter. Pipe rings shall be of malleable cast iron or fabricated steel, made in halves and secured by bolts or screws. Alternatively, malleable iron hinged pipe rings may be used, but calliper hooks will not be permitted.

Z. Pipework supports shall be arranged so that minimum stress is imposed upon the pipelines. Provide additional supports on either side of pipework ancillaries and equipment such as valves, strainers, and heating coils and other pipeline mounted equipment. It is important to ensure that all materials used for pipework supports are compatible with the pipeline materials

AA. Installation of Flexible Grooved end expansion joints

1. Install in accordance with OEM Manufacturers instruction manual.

2 A OEM Factory trained field representative shall provide on- site training for contractor’s field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review to ensure contractor is following best recommended practices in grooved product installation. (A distributor’s representative is not considered qualified to conduct the training or jobsite visit(s).

- All mild steel supports and channels shall be replaced with GI or mild steel with Zinc coating

Copyright © Buro Happold Limited

3.2 INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-NMEJ-702 “Rubber Flanged Non-Metallic Expansion Joint. Installation, Maintenance and Storage”

E. Install grooved-joint expansion joints to grooved-end steel piping.

Copyright © Buro Happold Limited

FOR ELECTRICAL PART, PLEASE REFR TO THE ELECTRICAL TENDER SPECIFICATION

DOCUMENT ISSUED. – This section is only valid for all M and PH & FP specification

Copyright © Buro Happold Limited

INDEX

VOLUME	SECTION	DESCRIPTION		PAGE NO.
VOLUME - 02	B.5	TESTING & COMMISIONING		
		1.1	SUMMARY	1
		1.2	SCOPE OF WORKS	1
		1.3	QUALITY ASSURANCE	2
		1.4	SUBMITTALS	3
		1.5	FACTORY TESTS	4
		1.6	ON-SITE TESTING AND COMMISSIONING	5
		1.7	TESTING AND COMMISSIONING OF FIRE PUMPS AND ANCILLARIES	7
		1.8	TESTING AND COMMISSIONING OF WATER SUPPLY SYSTEM	8
		1.9	TESTING AND COMMISSIONING OF DRAINAGE SYSTEM	11
		1.10	TESTING AND COMMISSIONING OF HVAC SYSTEM	12
		1.11	STATUTORY AUTHORITES TEST AND INSPECTIONS	22
		1.12	PRELIMINARY COMMISSIONING CHECKS	22
		1.13	COMMISSIONING	22
		1.14	FINAL ACCEPTANCE TESTS	22
		1.15	REJECTION OF PLANT	23
		1.16	HANDLING OVER OF DOCUMENTS	23

Copyright © Buro Happold Limited

1.1 SUMMARY

A. Employ the services of an independent specialist commissioning subcontractor to programme, commission and collate test results.

B. The Contractor shall provide skilled technicians/engineer to commission the plant and associated controls to the satisfaction of the Owners representative.

C. Provide all necessary attendance to operate and maintain the plant and equipment during the commissioning period as required to suit the needs of the specialist commissioning contractor.

D. The technicians/ engineers will be required to demonstrate the correct procedures in starting and stopping the plant, running the various items of equipment under automatic and manual control and the correct maintenance of the plant.

E. This section provides a framework for the testing, regulation and commissioning procedures to be employed.

F. The scope of the works in this section may be divided into three stages:
- Pre-installation stage
- Installation stage
- Commissioning stage

G. Final approval of commissioning of the System / equipment is subjected to clearance of Local municipal corporation,CFO & LEED commissioning consultant.

H. The repetition of any test or commissioning shall be done if warranted by the Statutory Authority.

1.2 SCOPE OF WORKS.

A. Pre-Installation Stage

1. Ensure that sufficient valves, test points, dampers etc. are incorporated and correctly located to allow satisfactory testing, regulating and commissioning.
2. Ensure that all provisions for commissioning are included in the working drawings prior to being sent to the Owners representative.
3. Produce an agreed programme and method statements for the commissioning works for approval by the Owners representative.

B. Installation Stage

1. Undertake all tests and collate and witness all tests.
2. Ensure that all water systems have been properly cleaned, flushed, filled and vented.
3. Ensure that all air distribution systems have been properly cleaned and checked.
4. Prepare method statements for the commissioning of each system.
5. Attend the manufacturer's / supplier's works for performance tests on all major items of plant and equipment including, but not limited to, the following:
    a) MCCs
    b) Fire pumps
    c) Domestic & Grey water Pumps
    d) Drainage pumps
    e) Generators
    f) HV and LV switchgear
    g) HVAC Equipments
        - Air cooled chillers
        - Chilled water pumps
        - Outside Air handling units(OAHU)
        - Smoke and Ventilation fans

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – E

SCHEDULE OF DEVIATIONS FROM TECHNICAL SPECIFICATION

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

NOTE FOR TENDERER:-

The Tenderer shall carefully study all the requirements of the specifications and drawings and indicate all deviations from technical specifications and Tender Drawings in this section only. Deviations indicated elsewhere in the package or bid will not be considered for evaluation.

SR.NO	REFERENCE CLAUSE	DESCRIPTION	DEVIATION DETAILS

We confirm that all the deviations from Technical Specifications and Tender Drawings are listed as above.

Seal of the Tenderer **Name:**

Designation:

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – F

SCHEDULE OF DEVIATIONS FROM GENERAL & SPECIAL CONDITIONS OF CONTRACT, BOQ/SCHEDULE OF PRICES

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

NOTE FOR TENDERER:-

The Tenderer shall carefully study all the requirements of the general & special conditions of contract and BOQ / Schedule of prices & indicate all deviations in this section only. Deviations indicated elsewhere in the package or bid will not be considered for evaluation.

SR.NO	REFERENCE CLAUSE	DESCRIPTION	DEVIATION DETAILS

We confirm that all the deviations from general & special conditions of contract and BOQ / Schedule of prices are listed as above.

Seal of the Tenderer

Name:

Designation:

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – G

LIST OF APPROVED MAKES

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

HVAC SYSTEM

Sr. No.	Details of Materials / Equipment	Manufacturer's Name
1	Constant Volume Air cooled Split AC Units	Carrier Daikin Hitachi Voltas Blue Star
	Variable Refrigerant Volume / Variable Refrigerant flow system	Toshiba Daikin Hitachi Mitsubishi
2	Variable Frequency Drive Automatic AFD Bypass Differential Pressure Sensor / Transmitter	Danfoss ABB Schneider Siemens
3	Anti corrosive coating on condenser / evaporator / Cooling Coils	Blygold
4	Centrifugal Fan	Greenheck, Kruger Nicotra Nuaire
5	Vane / Tube Axial Flow Fan	Greenheck Kruger Nicotra Nuaire
6	Inline/Propeller Fan/Roof extractor Fan/ Cabinet type fans	Greenheck Kruger Nicotra Nuaire
7	Volume Control damper(VCD) & Pressure relief damper	Caryaire Ravistar Greenheck
8	Hangers & Supports	Hilti Fischer Arrow HITECK
9	Acoustic Insulation: a. Nitrile Rubber b. Fiber glass	Armacell- Arma sound Owen Corning UP Twiga
10	Copper Pipes	Mandev Rajco

Copyright © Buro Happold Limited

11	GI Sheet	ESSAR Jindal SAIL TATA
12	GI Factory Made Duct	Rollastar Zeco Ductofab Alpha duct
13	Air Inlet / out let	Caryaire Cosmos Ravistar Air master
14	Smoke / Fire Damper & Motorized Fire & Smoke Damper	Caryaire Ruskin GreenHeck Ravistar Betec CAD
15	Sound Attenuator	Ravistar Caryaire George Rao Uniflair
16	Anchor Fastener	Hilti Fischer Shakti
17	Filter Drier	Danfoss Sporlan Mueller Industries Safe A & T Technology
	Insulation	
18	Closed Cell Elastomeric nitrile rubber along with adhesive	Armacell-Armaflex Eurobatex- Union foam K-Flex A-Flex
19	Fiberglass (Foil Faced)	Owens Corning UP Twiga
20	Fiber Glass(Hard Board)	Owen Corning Up Twiga
21	Closed cell Nitrile Rubber	Armacell Armaflex K-Flex Superlon
22	Over deck Insulation	Isoboard Owens Corning Polybond Thermosheild
23	Protective Coating over Closed Cell Elastomeric – Fiber glass Woven Clothe	UP Twiga, Foster

Copyright © Buro Happold Limited

24	UV Protective coating	Amicol Polybond Foster
25	Fire Sealant	BTHM Engineering Birla 3 M Hilti Promat
26	CONTROLS	
27	Humidistat	Honeywell Invensys Johnson Control Siemens
28	Dial Thermometer Capillary Type.	Penn Tadington
29	Air Flow Switch	Danfoss Rapid Control Siemens Honeywell
30	Pressure Gauge	Emerald Fiebig H. Guru
	MISCELLANEOUS	
31	Vibration Isolator	Dunlop Flexionics Kanwal Industries Corporation Resistoflex
32	Flexible duct connector	Mapro Kanwal Industries Corporation Resistoflex
33	Power Cables / Control Cables	Polycab Rallison Avocab KEI

Note : Preference will be given to use maximum number of available components from the selected manufacturer for the project.

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – H

PREAMBLE TO BILL OF QUANTITY

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

1.1 GENERAL

A. The Bills of Quantities herein, including all notes and instructions, form an integral part of the Contract Documents. However, the descriptions contained in the Bills of Quantities for each item are not necessarily complete.

B. The rates for each item must be comprehensive and must include for complying with the Specifications, and all obligations under the Contract including all matters and things necessary for the proper construction, completion and maintenance of the Works. No claims for additional payment will be allowed for any error or misunderstanding by the Contractor of the work involved.

C. The rates for each item must allow for all costs and expenses in complying with all general risks, liabilities and obligations set forth in the Drawings, Specifications and Conditions of Contract, including but not limited to the following :
   a. Labour, supervision and all associated costs.
   b. Materials, goods, consumables and all associated costs.
   c. Fitting and fixing materials and goods in position
   d. Provision of plant, equipment and tools
   e. Restriction of working areas and procedures
   f. Temporary works
   g. Establishment, administration and overhead charges and profit

D. Where quantities are indicated to be “Provisional” they shall be included in total scope of works. The value of the works shall be paid to the Contractor as per milestones, the milestones works to be assessed by Project manager along with Contractor’s representative, and the Contract Price shall be adjusted accordingly.

E. The prices and rates entered by the Contractor against items in the Bills of Quantities shall apply throughout the duration of the Contract to the execution of these items in any location and, these rates will be used as a basis for evaluating of Variation items provided for, to any additional work ordered by the Client/Consultant.

F. A price or rate is to be entered against each item in the Bills of Quantities and any item left unpriced will be deemed to be included in the total tendered price and hence the rate for that item will be taken as nil.

1.2 METHOD OF MEASUREMENT

A. The quantities in the Bills of Quantities have been prepared generally in accordance with IS 1200 method of Measurement. The description of each item (which description shall imply references to any heading, sub-heading, preamble or other clause of item which shall apply) shall be held to include all claims, materials, workmanship, including all taxes, duties, charges, all Government levies, landing charges, transport, packing, forwarding, AMC, insurance, handling, loading, unloading, profit and overheads and all other incidental costs to complete the Works.

B. The Contractor shall not use these Bills of Quantities as a construction programmed or for the purposes of ordering materials or arranging sub-contracts. The references for these activities shall be the Drawings, Specifications and instructions issued by the Client/Consultant.

C. These preambles are to be read in conjunction with the Drawings, Specifications and item descriptions in the Bills of Quantities.

D. ‘As described’ means as described in the Specifications.

1.3 ABBREVIATIONS

A. In the Specification and Bills of Quantities the following abbreviations have the meanings hereby assigned to them :-

Approved /Approval - means approved by or approval of the Client / Consultant in Writing.

Copyright © Buro Happold Limited

Submitted / Submit	- means submitted to or submit to the Client / Consultant in writing
Accepted / Acceptance	- means accepted by or acceptance of the Client / Consultant in writing
Inspected / Inspection	- means inspected by or inspection of the Client / Consultant
Directed	- means directed by the Client / Consultant in writing
Authorised / Authority	- means authorised by or authority of the Client in writing.
Required	- means required by the Client in writing
Rejected	- means rejected by the Client in writing
In writing	- above shall also mean verbally later confirmed in writing
Mm	- millimetre
m	- Linear metre
m^2	- Square metre
m^3	- Cubic metre
Kg	- Kilogram
KN	- Kilo Newton
MPa	- Mega Pascal
No /Nos	- Number
Pc	- Piece or number
T	- Tonne
IR	- Item Rate Only
R.O	- Rate only

1.4 PREAMBLES

A. Rates for all work shall include for protection and provision of samples.

B. All measurements are net and the total price shall include for all laps, waste, working space and trade or traditional allowances.

C. The pricing of materials shall take account of the following :
   1. Materials shall be of the quality specified unless otherwise directed by the Client / Consultant.
   2. All materials shall be transported, handled, stored and fixed in accordance with the printed instructions or recommendations of their manufacturers or suppliers.
   3. Protection of completed work, all casings and temporary coverings and making good, cleaning and polishing and clearing away upon completion.

1.5 PRICING

A. The prices shall be comprehensive and must include for complying in all respects with the Conditions of tender, Conditions of Contract, Specifications and Drawings and for all matters and things necessary for the proper construction, completion and maintenance of the whole of the Works. No claims for additional payment will be allowed for any error or misunderstanding by the Contractor of the Work involved.

B. Tenders shall be on a item rate basis for items/equipment delivered, installed, tested & commissioned at site. During the contract period and till the completion of work in all respects, prices shall remain firm & free from variations due to rise and fall in cost of materials, equipment, labour or any other reason what so ever contractor shall be paid as per erected qty at site.

C. All prices indicated shall be inclusive of the price for design verification, drawings, manufacture, supply, handling at site, installation, testing, commissioning, balancing and handing over, unless otherwise specified.

D. All prices indicated shall be inclusive of all applicable taxes, duties and other levies such as excise duty, sales tax, turnover tax, fabrication tax, works contract tax, octroi etc. Packing & forwarding, transportation, insurance, loading, unloading and installation charges (including erection, testing commissioning & handing over) Nothing extra shall be payable except statutory changes

Copyright © Buro Happold Limited

in taxes & duties. Any adjustment due to statutory changes in taxes & duties shall be made only in the final bill based on submission of proper authenticate and adequate documentation.

E. Bidder shall fill the enclosed Bill of Quantity only.

F. The price shall be filled-in ink and no over-writing, rubbing etc. is allowed. If for any reason prices are cut and changed, Bidder shall clearly sign at the respective locations.

G. Bidder shall indicate rates for all the items mentioned under OPTIONAL ITEMS in the price schedule. These rates shall be applicable if any of the said items are used during the execution of the contract.

H. The Bidder shall furnish all the information called for in Section C, D, E & F of tender Document, failing which the Bid will be treated as incomplete and the Client/Consultant reserves the right to reject the Bid. The Bidder is advised to fill information strictly in the format enclosed.

I. The Bidder shall carefully study all sections and drawings enclosed (if any) with specification and indicate deviations in the Section E & F of the Specification. If no deviations are stated it will be assumed that the offer conforms in all respects to the specification and the Client reserves the right to evaluate the Bid as such without further reference to the Bidder.

J. Lump sums shall not be given where unit rates are applicable.

K. Where the word “allow” is used, the cost of the item shall be the responsibility of the Contractor to allow and include cost of entire scope work.

L. The amounts set against any item of overhead shall include for all costs in connection with letters of credit, bank charges, interest charges and insurance after the materials, come under the control of the Contractor.

M. The rates inserted will be used to determine the amount of the Contractor’s Interim Payments.

N. The Tenderer shall submit the analysis of the “Tender Sum” with a full and detailed rate breakdown of all the BOQ items including spare parts items, together with their tender submission. The breakdown is to show the actual calculations of the General Items, labour, Plant and Materials, Cost for the Works, the build-up of measured rates with on-costs and overheads and any other allowances used to arrive at the Tender Price. In addition the Tenderer/Contractor will be required to provide the Client within 48 hours with a full and detailed breakdown/ any other information if requested.

O. The rates inserted in the Schedule of Day works if any, shall be deemed to be the rates used by the Main Contractor in making up rates for works items in all parts of the Bills of Quantities.

1.6 VARIATIONS

A. Consultants/Client shall have the power from time to time in the execution of work by notice in writing to instruct the Contractor to make any alteration, omission, addition or variation in the work (herein after referred to as ‘Variation’). The difference in cost of such variation shall be added to or deducted from the contract price as the case may be in accordance with the rates applicable in the Contract. In case these rates are not available in the contract, they shall be agreed between the CLIENT and the Contractor. If the variation required by the Consultants in the opinion of the Contractor involves a claim for additional payment or prevents him from meeting any of his obligations to guarantees in the Contract, he shall immediately notify the Consultants in writing failing which he shall not be entitled to any modification in his obligation or for additional payment. If Consultants do not admit that the variation required by him involves additional payment to the Contractor or modification in the obligations of the Contractor, the variation required shall nevertheless be carried out and the matter of difference settled between the CLIENT and the Contractor.

B. The Consultants shall give a reasonable notice to the Contractor to enable him to make arrangements for variations in work required by him.

Copyright © Buro Happold Limited

C. CLIENT reserves the right to omit or alter some or all the items at any stage of the work and the contract value will be adjusted accordingly.

1.7 SHOP DRAWINGS

A. The rates in the appropriate section shall include for design of the elements as specified in the Contract and for providing Design Verification, working drawings, shop drawings, schedules, specifications, calculation, Installation, Testing, Commissioning etc and for obtaining the Client / Consultant's approval.

1.8 SITEWORK

A. The Tenderer is hereby notified that all the BOQ Quantities are indicative and quantities measured as approximate the valuation works as per assessed milestone basis.

B. For excavation work no allowance for increase in bulk or working space.

C. The Tenderer shall allow in his rates for excavation for excavating in any material including running silt, running sand and rock, commencing excavation of any depth, excavating below the normal water table, excavating around existing services and mains, supporting the vertical sides of excavations, working space and filling soft spots.

D. Rates for disposal of excavated material shall include for any necessary double handling and the provision of a tip, if necessary, including any charges in connection therewith.

E. Wherever the term 'dispose on site' is stated within the earthworks section of the Bills of Quantities, the quantities of surplus excavated material shall either be required to be used elsewhere in the contract or stockpiled on site in a location approved by the Project Manager.

F. Wherever the term 'filling to make up levels' is stated within the earthworks section of the Bills of Quantities, the additional quantities of fill material required shall either be taken from elsewhere in the contract or from the stockpiles of surplus excavated material located on site.

G. Rates for excavation of trenches for pipes, cables and the like shall include for compaction, disposal, dewatering and filling with selected excavated material, hand and machine compacted as specified.

H. The rates for drains, inspection chambers, etc., are to allow for testing.

I. Rates for drain pipes generally are to include for all short lengths, back stops, wooden plugs and retaining and alignment pegs required in laying and for the extra involved over normal trench excavating in hand packing and tamping selected fine material around the lower half of the pipes to buttress them against the side of the trench. Rates are to include for leaving all pipes clean and clear.

J. Pipes are measured net works as laid and are to include for all drain fittings on all types of drain pipes, extra joints of all types and cutting and waste on all pipes, for laying in trenches of any depth, and building in to sides of inspection chambers.

K. Rates for drain accessories shall include for concrete surrounds and any additional excavation and disposal.

1.9 METALWORK

A. The rates for all steelwork and metalwork shall include for the following :
   a. Ends, angles, intersection, ramps on frames, bearers, bars, rods, angles, channels, I beam etc.
   b. Assembling and jointing together components
   c. The weight of weld metal in welded constructions
   d. Members of any length
   e. Cutting to size and shape and joints in the running length
   f. Notches, holes, slots, mitres, angles, ends and for all drilling and splay cut ends

Copyright © Buro Happold Limited

g. Grinding welds to a smooth finish, unless otherwise required
h. Fixing with appropriate non-corroding countersunk screws including holes unless otherwise described.
i. Riveted and bolted work shall include rivets, bolts and holes and countersunk holes
j. Approved protection to cut ends or holes in galvanised work or other applied finish
k. All considerations arising from the Specification
l. Floor plates, duct covers and the like shall include narrow widths, laying in position, frames and for all holes, slots and the like and making good
m. All preparation, protection coatings and final decoration with the items to which they relate
n. All fittings and fixing required, including grouting in position

B. "Welding" is deemed to be in accordance with the specification and for the material to which it is to be used.

1.10 FITTINGS AND FIXTURES AND ACCESSORIES

A. General
a. For the purposes of identification, fittings fixtures and accessories to be measured in accordance with the principles in this section shall be defined as those being specially manufactured or proprietary items not included in other section.
b. Unless otherwise described or measured as whole item work in this Bill of Quantities, prices for all items shall include for all necessary straight, raking or circular cutting, pipe fittings, bends, elbows, end caps, pipe supports, concrete thrust-blocks, pipe beddings and surrounds etc. for the completion of the whole of the works as specified and shown on the drawings.

1.11 MECHANICAL WORK

A. Sundries
a. Rates for the documents shall include for providing design verification, as built drawings and shop drawings, operating instructions and maintenance manuals within the time period as specified.
b. Rates for the incidental works shall be deemed to include for cleaning and sterilising.
c. Modifications to existing works shall be measured as whole items where appropriate. Making / breaking and remaking surfaces to match/ join the existing shall be deemed to be included.

B. Ductwork
a. Measurement of ducting will be based on the external surface area of the fabricated/installed ducting including all materials and labour, only measured as whole work, but not as a unit.
b. Duct Work shall be measured based on external surface area of ducts.
c. 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.
d. For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centre line distance between the flanges of the duct section.
e. 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 3 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.

Copyright © Buro Happold Limited

f. Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.
g. Diffusers - cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
h. 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.
i. Fire / Smoke dampers - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream. Control panel for Fire/Smoke dampers shall be measured by numbers which shall include FRLS cable for interconnection of control panel, actuator & AHU panel. No additional payment on account of FRLS cable shall be made.
j. Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.
k. The price include Sleeve, flanges, gaskets for joints, bolts, nuts, duct supports, hangers, vibration isolation pads, suspenders, flexible connections, inspection doors, turning vanes, straight vanes and any other item which will be required to complete the duct installation , external insulation and acoustic lining are measured separately.
In case of taper pieces, average width and depth will be worked out as follows:

W1 - Width of small cross section
W2 - Width of large cross section
D1 - Depth of small cross section
D2 - Depth of large cross section
Average Width – (W1 + W2)/2
Average Depth – (D1 + D2)/2

For the special pieces like bends, branches, tees, etc. the same principle of area measurement as for linear lengths will be adopted. The length of bends and elbows will be the average of the lengths of inner and outer periphery along the curvature.

C. Automatic Controls
a. Sensing or activating devices, control panels, air compressors and receivers or the like shall be deemed to be included in the respective items.
b. Wiring, pneumatic tubing, isolators, starters, relays or the like associated with automatic controls shall be deemed to be included.

D. Insulation including Linings and Protective Coverings
a. 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.
b. 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.
c. Insulation boxes around accessories shall be deemed to be included.
d. Rates for insulation are to include for cutting and waste, jointing laps and for working around and over ancillaries, fittings, flanges, and other obstructions.
e. Duct Insulation and Acoustic Lining shall be measured on the basis of surface area along the centre line of insulation thickness. Thus the surface area of externally thermally insulated or acoustically lined be based on the perimeter comprising centre line (of thickness of insulation) width and depth of the cross section of insulated or lined duct, multiplied by the centre-

Copyright © Buro Happold Limited

line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

E. Beds, Hunching and Surroundings
   a. Beds, hunching and surrounds as specified shall be deemed to be included with the respective item length.

F. Measurements for Ducting
   a. 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.
   b. For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centre line distance between the flanges of the duct section.
   c. 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.
   d. 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 3 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.
   e. Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith :
   f. Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.
   g. Diffusers - cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
   h. 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.
   i. Fire dampers - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream.
   j. Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.

1.12 ELECTRICAL WORK

A. Main Circuits
   a. Cable to distribution boards and the like shall be measured in liner meters.
   b. Cable terminations shall be separately enumerated.
   c. Any kind of ‘conduit’ as defined above shall be deemed to be included with cable / wire.

B. Sub-Main Circuits
   a. Cables to individual sub-main circuits shall be measured by length stating the cable type and size.
   b. Terminations to individual circuits as indicated on the drawings shall be separately enumerated.

Copyright © Buro Happold Limited

c. Any kind of 'conduit' as defined above shall be deemed to be included with cable / wire.

C. Control Gears
   a. Rates for all electrical panels shall include for supply and installation of all necessary MCCB's, MCB's, EFR's, ELCB's auxiliary contacts, Volt meters, ammeters, kWh meters, indicator lamps, selector switches, inter connecting copper bus bars, interlocks aligning and grounding the panel, interconnections, internal wiring instrument wiring loops, connecting to switch gears, cable gland lugs, steel channels and necessary hardware fixing and insulating materials with fully enclosed panels and distribution boards where ever necessary and complete as shown in drawing and comply with the specifications, and as per relevant latest standards and regulations and all complete to working order to the approval of the Consultant.
   b. Rates for medium voltage panels shall include for any special fabrications, mountings, special finishes, chemical pre-treatment's and cleaning process.
   c. Rates for all panel boards shall include for making separate compartment for incomer and inter phase barriers.

D. Meter boards
   a. Rates for meter boards shall include for 20mm thick teak wood board, energy meters, current transformers, MCBs, /MCCBs/ SFUs, sheet steel enclosure, mounting bracket, framework and finishes etc.

E. Small power & lighting installation
   a. Rates for small power point wiring shall include for supply & installation of sockets, fixtures, face plates, conduits, wires, junction boxes & accessories.
   b. Rates for lighting point wiring shall include for supply & installation of conduits, wires, junction boxes & accessories, holders, ceiling rose, fixing blocks etc. Lighting switches shall be separately enumerated.
   c. Special lighting such as aviation lights shall be enumerated. All relevant cabling, conduits, fittings, fixings and control units shall deemed to be included in the lights.
   d. Rates for lighting fixtures shall include for supports, brackets, mounts, hangers etc.

F. Cable trays
   a. Rates for cable trays shall include for all fittings and supports.

G. Excavating Trenches for Cables
   a. Excavating trenches for cables irrespective of the depth shall be deemed to be included in respective item length.
   b. Disposal, backfilling, compacting and grading bottoms and supporting sides of excavation, etc. shall be deemed to be included, in respective item length.

1.13 ADJUSTMENT ITEM

A. General
   a. Where the Amount of Tender is computed by a Tenderer by making a lump sum adjustment to the summed total of the Bill of Quantities or to the summed total of a section of the bill of Quantities, then the lump sum adjustment so made will be deemed to apply proportionally to the individual rates and prices throughout the Bill of Quantities, or throughout that section of the Bill of Quantities respectively.
   b. Such proportional adjustment shall not be applied to any Provisional Sums given in the Tender Documents.

   c. Such proportionally adjusted rates and prices shall be those rates and prices used later during the currency of the Contract to assess the value of variations to the Contract and for the valuation of measured work done for interim payments.

Copyright © Buro Happold Limited

1.14 PROPRIETARY MATERIALS

A. Where manufacturers names of proprietary material names are given against certain items in the Bills of Quantities, the rates and prices inserted shall be for those specified material or other similar and approved materials.

1.15 MATERIALS AND WORKMANSHIP

A. Tenderer's are referred to the specification forming part of the contract documents, together with the notes on all the contract drawings for the standard of materials and workmanship to be used in construction.

B. Where not elsewhere defined, standards are to be not less than those specified in relevant British / Indian Standards and Local Authority's Codes of Practice currently in force.

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SECTION – I

BILL OF QUANTITY (BOQ)

BH-ZSG-BOQ-M-0001

BUROHAPPOLD ENGINEERING

01	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

LODHA PLOT C SALES GALLERY INTERNAL HVAC BOQ-R01

Item	Description	Qty	Unit	Unit rate for Supply (Rs)	Total amount for Supply (Rs)	Unit rate for Labour (Rs)	Total amount for Labour (Rs)
A	**AIR SIDE**						
1	**Indoor Units For VRV/VRF System**						
1.1	Supply,instllation in position ,testing,commissioning of **Hi-wall type** room unit for **Show flat area** suitable for wall mounting, complete with filters, DX cooling coils with anti corrosive coating,refrigerent piping and accessories with insulation,connected to variable refrigerant volume / flow system, fans, 3speed motors, power wiring from nearby socket, with necessary valves and internal piping insulated Condensate drain pan and connection , copper connections, IR Sensors, RA sensors, remote control with associate cabelling, vibration isolators and in accordance with specification, drawings and equipment schedule.						
i	SF-IDU-001	1	Nos.				
ii	SF-IDU-002	1	Nos.				
iii	SF-IDU-003	1	Nos.				
iv	SF-IDU-004	1	Nos.				
v	SF-IDU-005	1	Nos.				
vi	SF-IDU-006	1	Nos.				
1.2	Supply,installation in position ,testing,commissioning of **Ducted type** room unit suitable for ceiling mounting, complete with filters, DX cooling coils with anti corrosive coating refrigerent piping and accessories with insulation,connected to variable refrigerant volume / flow system, fans, 3speed motors, necessary valves with piping,power wiring from nearby socket, insulated drain pan with extended insulated drain tray,RA sensors, IR sensors (Receiver kit with remote) with associated cabelling, copper connections, vibration isolators,etc. and in accordance with specification, drawings and equipment schedule.						
i	SG-IDU-L0001	1	Nos.				
ii	SG-IDU-L0002	1	Nos.				
iii	SG-IDU-L0003	1	Nos.				
iv	SG-IDU-L0004	1	Nos.				
v	SG-IDU-L0005	1	Nos.				
vi	SG-IDU-L0006	1	Nos.				
vii	SG-IDU-L0007	1	Nos.				
vii	SG-IDU-L0008	1	Nos.				
ix	SG-IDU-L0009	1	Nos.				
x	SG-IDU-L0010	1	Nos.				
xi	SG-IDU-L0011	1	Nos.				
xii	SG-IDU-L0012	1	Nos.				
xiii	SG-IDU-L0013	1	Nos.				
xiv	SG-IDU-L0014	1	Nos.				
	To Collection					Rs.	
2	**Variable refrigerant flow condensing units**						
	Supply,installation in position ,testing of **Variable refrigerant flow / volume outdoor condensing unit** complete with compressors, air cooled condensers, motors, with anti-corrosive coating on coils for minimum life of 5 years,starters, gauges, necessary valves and accessories along with internal and external refrigerent piping connected between FCUs and out door unit,controls in microprocessor based control panels (starter panel), necessary hook up with indoor units / IR sensors with control cables, R410 as refrigerant, Refrigerant used shall be Ozone friendly and should not contain HCFCs and Halons, power peak control unit and all other standard accessories whether specifically mentioned or not including mounting on a rigid steel base frame with spring isolators of 25mm static deflection as detailed in specification and drawings and complying to necessary requirement with COP at ARI conditions. Unit control panel shall have the necessary provision in accordance with specification, drawings and equipment schedule.						
	SG-ODU-L0001	1	Nos.				
	SG-ODU-L0002	1	Nos.				
	SG-ODU-L0003	1	Nos.				
	To Collection					Rs.	
3	Supply, installation, testing and commissioning of direct driven **Circular Inline Fans** for Toilet exhaust & Fresh air as shown in drawings.Each fan shall be complete with permanent split capacitor or shaded pole motor, mounting plate, accessories like wire guard and gravity louvers for weather protection as required. The motor shall be suitable for 230 V + 6% volts, Single phase 50cycle, AC supply.The fan shall be low RPM and capacities based on minimum 25 mmwg ESP.						
3.1	SG-TEF-L0001	1	Nos.				
3.2	SG-FAF-L0001	1	Nos.				
3.3	SG-TEF-L0002	1	Nos.				
3.4	SG-FAF-L0001	1	Nos.				

Copyright © Buro Happold Limited

LODHA PLOT C SALES GALLERY INTERNAL HVAC BOQ-R01

Item	Description	Qty	Unit	Unit rate for Supply (Rs)	Total amount for Supply (Rs)	Unit rate for Labour (Rs)	Total amount for Labour (Rs)
4	Supply, installation, testing and commissioning of belt driven **SISW Centrifugal fan** for Kitchen exhaust as shown in drawings.Each fan shall be complete with permanent split capacitor or shaded pole motor, mounting plate, accessories like wire guard, bird screen and gravity louvers for weather protection as required. The motor shall be suitable for 230 V + 6% volts, Single phase 50cycle, AC supply.The fan shall be low RPM and capacities based on minimum 35 mmwg ESP.						
4.1	SG-KEF-L0001	1	Nos.				
B.	**PIPE & ACCESSORIES**						
1	Supplying, installing, testing and commissioning of **Refrigerant Copper Liquid piping** for connection between indoor and outdoor units of the capacities mentioned above with refnet joints & gas charging whenever required. Refrigerant piping shall be conforming to ASTM B68 / 1995 and ASTM – B75/1983 with 19mm thick nitrile rubber insulation including supports, necessary fittings, joints, brazing connections and necessary arrangement as per specification and to make system complete.						
	Length of pipe	174	RM				
2	Supplying, installing, testing and commissioning of **Refrigerant Copper Gas piping** for connection between indoor and outdoor units of the capacities mentioned above with refnet joints & gas charging whenever required. Refrigerant piping shall be conforming to ASTM B68 / 1995 and ASTM – B75/1983 with 19mm thick nitrile rubber insulation including supports, necessary fittings, joints, brazing connections and necessary arrangement as per specification and to make system complete.						
	Length of pipe	174	RM				
3	Supplying, installing, testing and commissioning of **High Pressure UPVC** conforming to IS:4985 complete with fittings and 'U' traps for Condensate Drain Piping with supports,necessary fittings to connect to **PP/UPVC pipe** , 9mm thick **Nitrile rubber** thermal insulation and suitable to withstand pressure rating of 2.5 bar to 12.0 bar as per specifications.						
	Length of pipe	109	RM				
B	**DUCTS**						
1	**Normal Ducting**						
	Supply, installation in position and testing of G.I. sheet metal Factory fabricated ducts in accordance with SMACNA complete with nuts,bolts,flanges,washers,sealents,spliter dampers,guiding vanes,access doors,non return dampers,elbows,supports,as per drawings and as required for air distribution. in accordance with the approved shop drawings and as required by the specifications.The rate shall include all materials and labour for galvanised steel suspension and supporting arrangement for Plenums, ducts complete with necessary arrangements as per specifications and drawings.						
1.1	26 Gauge	885	Sq.Mtr.				
2	Supply,installation,testing and commissioning of flexible connection from each Equipment intake/outlet to duct as indicated on drawings and wherever necessary along with necessary arrangement.	25	Sq.Mtr.				

Copyright © Buro Happold Limited

LODHA PLOT C SALES GALLERY INTERNAL HVAC BOQ-R01

Item	Description	Qty	Unit	Unit rate for Supply (Rs)	Total amount for Supply (Rs)	Unit rate for Labour (Rs)	Total amount for Labour (Rs)
C	**THERMAL/ACOUSTIC INSULATION**						
1.0	Supply and installation in position testing of **External Thermal insulation with closed cell nitrile rubber** with 30 micron aluminium foil with thermal conductivity of not less than 0.037w/mK with gasket ,sealent,fixing clips etc as per specifications drawings and sutaible for AC duct application. Insulation material shall be non-toxic, chemically inert, non-combustible as per BS 476: Part 4, non-ignitable as per BS 476: Part 5, and class 'O' as per BS 476 Part 6 &7 and also shall confirm IS 8183 as per specifications.						
1.1	19 mm thick for Supply air Duct	705	Sq.Mtr.				
1.2	19 mm thick for Return air Duct	180	Sq.Mtr.				
2	Supply and installation in position testing of **Nitrile rubber Accoustic insulation for supply air ducts** with density and thickness as per specification, complete with sealent,fixing clips etc. complete in all respect and in accordance with specification and drawings. Insulation material shall be non-toxic, chemically inert, non-combustible as per BS 476: Part 4, non-ignitable as per BS 476: Part 5, and class 'O' as per BS 476 Part 6 &7 and also shall confirm IS 8183 as per specifications. The thickness of the insulation shall be as per specifications						
1.1	19 mm thick for Supply air Duct	37	Sq.Mtr.				
D	**DAMPERS**						
	VOLUME CONTROL DAMPERS						
1	Supplying Installation,Testing &commissioning of opposed blade type **volume control dampers** of robust 16 G GSSconstruction with all necessary links,accessories,suporting arrangement,nuts,bolts,gasket etc. in supply air, return, Fresh air & Extract air duct collars as per approved drawings and specifications and as required to do the sucessful commissioning and balancing of the air side of the system and to suit the following duct size.	23	Nos				
	To Collection					Rs.	
E	**GRILLES & DIFFUSERS**						
1	Supply,Installation ,testing and commissioning of **linear bar grille** complete with Collar dampers,accoustic lined plenum,nuts,bolts, gaskets,screws,supportis,fixing clips,with powder coated aluminium construction,with 6.4 mm wide bars on 12.5 mm centres pressed into notched steel retaining bar and in accordance with specification and drawings. Colour to be coordinated with architects.						
1.1	150 mm Wide	192	RM				
	To Collection					Rs.	
2	Supply, installation in position , testing and commissioning Powder Coated Extruded Aluminium **Air transfer door grilles** with powder coated extruded aluminium construction,with rear side frame as per approved shop drawings and specification.Colour to be coordinated with architects.						
2.1	500 mm X 300 mm	1	No				
2.2	400 mm X 300 mm	3	No				
2.3	300 mm X 200 mm	2	No				
2.4	750 mm X 450 mm	1	No				
F	**LOUVERS**						
1	Supply, installation in position, testing and balancing of air **louvers** with bird screen and volume damper for **fresh air intake** along with,nuts,bolts,gaskets,flanges,as per specifications and approved shop drawings with minimum 50% free area.Colour to be coordinated with architects. Powder coated/Anodised extruded aluminium construction.	38	Sq.Mtr.				
2	Supply, installation in position, testing and balancing of air **louvers** with bird screen and volume damper for **exhaust air along** with,nuts,bolts,gaskets,flanges,as per specifications and approved shop drawings with minimum 50% free area.Colour to be coordinated with architects. Powder coated/Anodised extruded aluminium construction.	38	Sq.Mtr.				
3	Supply,Installation,testing and commissioning of **Galvanised Iron** safety wire mesh at inlet/outlet of open supply/extract ducts complete with necessary nuts,bolts,gaskets,screws,supports and in accordance with speciifcation and drawings	10	Sq.Mtr.				
	To Collection					Rs.	

Copyright © Buro Happold Limited

LODHA PLOT C SALES GALLERY INTERNAL HVAC BOQ-R01

Item	Description	Qty	Unit	Unit rate for Supply (Rs)	Total amount for Supply (Rs)	Unit rate for Labour (Rs)	Total amount for Labour (Rs)
G.	**ELECTRICAL WORK**						
	XLPE un-armoured control cabling						
1	Cable terminations for XLPE insulated, PVC sheathed, 1100 V, un-armoured copper conductor, control cables including stripping of cable insulation, supply and fixing of tinned plated Copper lugs and crimping the same to the conductor, supply and fixing of double compression cable glands of the following cables complete as per technical specifications, drawings, relevant standards & site conditions.						
i	2C X 1.5 sq mm Cu	28	Nos.				
2	Supply, install, test and commission of XLPE insulated, PVC sheathed, 1100 V, un-armoured copper conductor, control cables including stripping of cable insulation, supply and fixing of tinned plated Copper lugs and crimping the same to the conductor, supply and fixing of double compression cable glands of the following cables complete as per technical specifications, drawings, relevant standards & site conditions.						
i	2C X 1.5 sq mm Cu	258	RM				
3	**Cable Trays**						
	Design, Manufacture, Supply, Unloading, Handling, & Installation of heavy duty hot dipped galvanised cable tray of the following sizes, suspended from ceiling or fixed vertically on wall / column as per route directed at site, including requisite supports, hardware, elbows, bends, offsets, transitions, reducers, EMC straps, equipotential bonding etc. etc. All supporting structure & hardware including nuts & bolts etc. shall be hot dipped galvanised as approved complete as per technical specifications, drawings & relevant IS standards & site conditions. Fabricated accessories shall not be allowed with written permission from client .						
	For all containment ≥ 600mm web height should be 75mm and all containment <600mm web height should be 50mm						
	For all containment up to and Including 300mm , Thickness of Material to be 1.5mm						
i	50 mm web height	258	RM				
	TO COLLECTION					Rs.	
H	**SUNDRIES**						
1	Allow for all adjusting , Balancing, inspections, testing and commissioning including all off-site and factory testing to determine compliance with relevant specifications and standards of operating the completed installation and submitting all relevant test record.	1	Item				
2	Allow for providing all tools, spare parts and consumables .	1	Item				
3	Allow for provision of working and as built drawings.	1	Item				
4	Allow for providing comprehensive equipment documentation including operating instructions ,maintenance manuals, record documents, warranties, guarantees, drawings and the like	1	Item				
5	Allow for tagging labelling for pipe / duct identification/ painting	1	Item				
6	Allow for general provision for pipe / duct work installations including sleeves, seals, flashings, pipe stacks, ceiling eqpts, protection, painting and all other related works.	1	Item				
7	Allow for coordination with other service contractors.	1	Item				
8	Allow for necessary electrical connections to all HVAC equipments.	1	Item				
9	Contractor shall list here any other items not included above but necessary for the complete and satisfactory completion of each section of the work. Such items shall deemed to be included in other rates unless specifically listed here	1	Item				
10	Cutting and forming holes, mortises, chases or the like and making good	1	Item				
11	Allow for CFD analysis for the complete installations.	1	Item				
	TO COLLECTION					Rs.	

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

LIST OF DRAWINGS (LOD)

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

SR NO	DRAWING NUMBER	DRAWING NAME
MECHANICAL DRAWINGS		
1	BH-ZSG-STD-M-2000	HVAC - General Notes and Legend
2	BH-ZSG-STD-M-2001	HVAC - Standard details
3	BH-ZSG-SLD-M-2200	HVAC - VRF schematic
4	BH-ZSG-L00-M-2500	Ground floor HVAC plan

END OF SECTION

Copyright © Buro Happold Limited

LODHA

BUILDING A BETTER LIFE

RESIDENCES | OFFICES | RETAIL | IT CAMPUSES | SEZs

SCOPE OF WORKS (SOW)

BUROHAPPOLD ENGINEERING

00	Nov 2015	TENDER	TA	KJ		LODHA
Rev	Date	Issue	By	Checked	Approved	Client

1.1 SCOPE OF HVAC SYSTEM CONTRACTOR

A. Scope of works listed below shall not be considered as comprehensive description of the Contract, but only as an indication of the extent of works.

B. Design verification, Selection, supply, installation, testing, commissioning and handing over of HVAC system and equipment for the satisfactory operation of the plant.

C. Provision of Design Verification, detailed calculation, selection of equipment, working drawings and builder work drawings supply, installation, testing, commissioning and handing over for the complete HVAC System to the requirement as stipulated in this specification and local government authority shall be in the contractor's scope.

D. Contractor's equipment layout must comply with the space allocated for the same and as allocated in the Tender drawings.

E. Detailed plant room layout, calculation, and schematic diagram to justify the allocation of plant space / builder's work requirement shall be submitted. Supporting evidence such as equipment catalogues, etc. shall be submitted to substantiate the design.

F. Static testing of plant shall be provided.

G. Testing and commissioning of installation under normal operational conditions shall be conducted.

H. All electrical work from the source of supply (by others) at the HVAC System Plant Room including isolator switch / fuse switch / switch fuse, main HVAC System control panel, interfacing panel, supply and installation of conduit, wiring, cabling, cable trays, contactors, control, alarm system and accessories for the effective working of the plant shall be carried out.

I. Priming and finishing coats painting to all metal pipe work and equipment as per the standards.

J. Coordinated MEP services drawings, As-built drawings and operation / maintenance manual shall be provided.

K. Provide sleeves for ducts, pipes(at slab/wall penetration).Seal the gaps between pipe sleeves and pipe work / conduit, etc. if any with approved fire sealant.

L. Submission of relevant documentation to local government authority for approval and obtaining license, if required.

M. Two year warranty and maintenance service from the date of handover of the works shall be included in the offer.

N. The Heating, Ventilation and Air-Conditioning (HVAC) system shall comprise of following:

1. Fan coil units (FCU's) DX coil.
2. VRV / VRFs
3. Centrifugal, axial and propeller fans for mechanical ventilation systems.
4. Motor control centers.
5. Sheet metal ducts inclusive of fire rated duct work, external insulation (wherever applicable),acoustic lining, canvas connections, silencers, volume control dampers, fusible link and motorized fire/smoke dampers inclusive of duct mounted access panels etc.
6. Fire wrapping of ducts as required.
7. Vibration isolators for all HVAC equipment. Special care shall be given in the vibration and noise isolation of the plant rooms from areas adjacent to the occupied spaces and from the roof top equipments to areas below to achieve specified noise criteria.
8. Automatic controls and instruments.

Copyright © Buro Happold Limited

9. Containment, cabling, wiring and earthing from control panels, MCC panels to various refrigeration, air conditioning and mechanical ventilation equipment, control wiring and interlocking.
10. Cutting holes, chases and the like through all types of non structural walls, and finishing's for all services crossings, including sealing, frame work, fire proofing, providing sleeves, and cover plates, making good structure and finishes to an approved standard.
11. Provide larger size sleeve for crossing of pipe, ducts, conduits & cables through fire rated wall/partition. The sleeve shall be sealed with fiberglass and fire sealant of approved make. All non fire rated penetrations shall be sealed with PU Foam of approved make.
12. Design, supply, erection and testing of hangers , expansion joints and supporting system for said high rise structure for expansion/contraction, building construction joint, building sway, column shortening/creep and seismic requirements (complying to requirements of seismic zone 3). Refer to section B.1 Hangers & supports for the further details.
13. Balancing, testing and commissioning of the entire HVAC and mechanical ventilation installation and air conditioning system.
14. Test reports, list of recommended spares, as-built drawings, operation and maintenance manual for the entire HVAC installation.
15. Complete co-operation with independent commissioning agent and corrective actions on snag list points prepared by such independent commissioning agent.
16. Training of Owner's Staff.
17. Service during Defects Liability Period.

O. Extent of Work

In addition to the above, the Contractor's work shall include, but not be limited to the following items, clarifications and/or modifications:

1. It is the intent of the Specifications and Drawings to call for finished work, tested and ready for operation. Any apparatus, appliance, material or work not shown on Drawings but mentioned in the Specifications, or vice versa, and any incidental accessories or minor details necessary to make the work complete and perfect in all respects and ready for operation, even if not specified, shall be provided without additional expense to the Owner.
2. The Drawings indicate the various piping, duct and electrical systems schematically. No added compensation will be permitted due to field conditions and/or required coordination.
3. Where variances occur between the Drawings ,Specifications and BOQ, or within either document itself, the item or arrangement of better quality, greater quantity, or higher cost shall be included in the Contract Price. The Client will decide on the item and manner in which the work shall be installed.
4. If directed by the EMPLOYERS REPRESENTATIVE the Contractor shall, without extra cost, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.
5. In order to standardize manufacturers between contracts, this subcontractor should note with their Bid Proposal, any premium cost associated with a particular manufacturer as listed in specs/documents. The Owner reserves the right to select any specified manufacturer for a particular item or piece of equipment to achieve standardization for the project.
6. The HVAC Contractor shall develop and submit "Point Load" drawings with all weights listed at each point of rest or point of attachment.
7. The HVAC Contractor understands and accepts the fact that there will be no payment for material or equipment unless delivered to the job site. No payment will be made for shop fabrication or material fabricated and stored off site.

Copyright © Buro Happold Limited

8. The HVAC contractor shall include fire-safing and fire-stopping of all ducts , pipes and cables crossing fire rated walls and slab penetrations with the specified fire rated packing material to meet all applicable codes. Contractor to undertake and facilitate inspection of all fire stops from approved vendor with each fire stopped signed off from approved vendor/material manufacturer.
9. Furnish all access doors in ducts required for accessibility to HVAC work. Access doors shall match the fire rating of the partitions in which they are being installed. Contractors to provide details of access requirements such as temporary and permanent access panels in their shop drawings.
10. Contractor is responsible to repair damage to insulation that is caused during the execution of work.
11. Include any additional steel required for support of equipment, ductwork, piping, etc and any cast-in channels .Additional steel supports shall be shown to the Employer's Representative in detailed, engineered shop drawings within 12 weeks of award of this subcontract..
12. All means and methods of demonstrating air conditioning and ventilation systems is the responsibility of this HVAC contractor, including temporary volume dampers where downstream ductwork is not installed at the time of operation.
13. Provide pre-operational airside start up for all air conditioning and ventilation system required to accomplish testing for the HVAC and fire alarm system.
14. HVAC contractor will be responsible to submit a motor schedule to be issued to the Electrical contractor for his use and coordination. The HVAC contractor is responsible to coordinate the voltage requirements of all motors with the electrical drawings. Contractor must notify the Employer's Representative in the event of a discrepancy or conflict between the HVAC and electrical drawings. Contractor is to clarify this during time of submission of respective equipment..
15. The contractor shall provide drip pans with drain lines wherever piping passes over (within 3 feet from vertical face) electrical and/or telecommunication equipment or passing thru the room designated for this equipment. HVAC contractor is required to provide these drip pans, whether or not they are specifically identified on the drawings.
16. The contractor shall provide leakage testing of ductwork as follows: All shafts, medium pressure ductwork and concealed low pressure ductwork (i.e. within shaft, and above sheetrock ceilings). Low pressure ductwork in accessible ceilings will be visually inspected and a section per floor will be tested. In addition, duct leakage testing will be performed in phases as required by the EMPLOYERS REPRESENTATIVE. In accordance with the specifications.
17. The contractor will provide access doors in ductwork for fire and smoke dampers, and automatic temperature control devices to facilitate installation and/or service and maintenance requirements.
18. Blank-offs painted flat black at all unused portions of active louvers and Architectural air slots.
19. Provide prefabricated curbs for all fans and all duct penetrations through the roof.
20. Provide metal nosing at the entering and leaving edge of all duct work. All lining seams shall be totally sealed as to prevent any exposed fiberglass within the air stream and/or plenums.
21. The Contractor shall provide all insulation work as indicated and as specified for the work of this Contract
22. HVAC contractor is responsible to do design, installation and testing of hangers and supporting required for the system
23. The Contractor shall provide the services of an independent Testing & Balancing Firm to perform the air and water balancing of all mechanical systems. Air and water balancing agency is subject to EMPLOYERS REPRESENTATIVE approval and may be selected by the EMPLOYERS REPRESENTATIVE in order to maintain continuity and quality control. Con-

Copyright © Buro Happold Limited

tractor shall submit the name of the agency during the award process and indicate the cost differential if any between proposed subcontractors.

a. Balancing shall occur within two (2) weeks from the startup and activation of each system.
b. Balancing reports for each system shall be formally submitted within one (1) week from the completion of the balancing work.
c. Balancing work may not be continuous and may require the balancer to return to the jobsite several times to perform balancing work as systems are completed and has included all associated costs.
d. It is the intent that a single Testing and Balancing Contractor be retained to perform all

1. air and water balancing for the project. The Contractor shall submit the name of the balancing firm with his bid and provide a breakout price for these services.

24. The Contractor shall perform system testing in accordance with the following:
    a. The testing of systems will be performed by zones and, at the direction of the Employer's Representative, in sections on a floor-by-floor basis, or in sections that are to be concealed by construction prior to completion of entire piping section / riser/ mains, etc.. Any additional equipment, devices, by-passes, fittings, etc., necessary to isolate systems or components of systems to implement such procedures shall be provided by the Contractor at no additional cost.
    b. All testing of concealed piping shall be performed in sections or phases prior to the installation of sheetrock and ceilings and, at the Employer's Representative's direction the entire system or entire section repeated.

25. The Contractor understands that testing work may not be continuous and may require the testing firm to return to the jobsite several times to perform testing as welds are completed and may require the submission of partial reports as work is completed. All costs associated with the performance of this work in such a manner are included. This Contractor will cooperate fully with and perform all work requested of said testing agency, inclusive of proving scaffolding or man-lift equipment to access the locations where tests are to be performed. Any welds not meeting the requirements of the specified standards shall be repaired and re-inspected at the sole cost of this Contractor without limitation.

26. Filter Requirements

    a. All HVAC Equipment shall be initially started up and operated with one (1) complete set of construction "pre" filters (filters as indicated in the "Construction & Startup" column above).
    b. Upon completion of equipment startup the initial set of construction "pre" filters shall be removed and replaced with a complete set of "pre" filters attached with clips to a complete set of "post" filters. This arrangement shall be used to perform the final equipment testing, adjusting, and air balancing, commissioning and turnover to Ownership (filters as indicated in the "Balancing & Commissioning column above.
    c. At the close of the project a complete set of "final" filters shall be delivered to the jobsite for turn over to Ownership (filters as indicated in the "Final" column above).
    d. All HVAC Equipment shall be delivered to the jobsite without any filters installed (all filters shall be shipped lose in separate deliveries from the equipment they serve).
    e. All sets of filters shall be furnished by the Contractor furnishing the associated equipment.
    f. The Contractor shall provide all labor associated with the receipt, handling, distribution and installation of all filters.
    g. Contractor is responsible to inventory and store pre-purchased air filters. Contractor is responsible to deliver and install filters as directed by Employer's Representative.

27. All equipment and materials shall be provided in strict accordance with the approved submissions bearing the approval stamps of the Employer representative.. Any equipment provided that deviates in any way from the approved submissions shall be removed from the jobsite within 24-hours notice from the Employer's Representative and replaced with the approved

Copyright © Buro Happold Limited

item(s). All costs related to such replacements, both direct and indirect, shall be the responsibility of the Contractor.

28. All equipment shall be stored off site shall be stored indoors without exception unless specifically approved for outdoor storage by the Employer's Representative. Note: All, fans, fan coil units, outdoor units, electrical equipment of any kind must be stored indoors.
29. The Contractor shall furnish and install all drain piping serving HVAC equipment (unless specifically indicated on the Plumbing Drawings). The contractor shall furnish and install any required drain piping from drip pans of HVAC equipment to nearest acceptable floor drain or mop receptor. This Contractor may review all Plumbing drawings and the piping shown relative to the make-up, storm reclamation tank and filtration system, cooling coil condensate reclamation. This contractor shall provide all work claimed by his trade in relation to this.
30. The Contractor is cautioned that the relevant standards of the local governing code and all governing agencies are to be strictly adhered to with respect to the materials used the method of installation and workmanship.
31. The Contractor shall be required to provide a detailed and comprehensive submission, in a format acceptable to the Employer's representative all other governing agencies, of the proposed method of fire stopping all conditions that will be encountered, along with all of the necessary supporting documentation indicating conformance to the appropriate UL Standards.
32. Access doors in finished construction for the Contractor's work shall be furnished and installed by that Trade providing the finish where the door is to be installed. However, the Contractor shall submit, for approval from the Employer's representative drawings describing the size, type and location of all required access doors. Upon receipt of the Employer's representative approval, the Contractor shall provide all coordination information to the installing Trade by furnishing approved installation location drawings and clearly marking (using a ribbon, temp sign, etc) each device installed in inaccessible spaces prior to the commencement of the finished construction. It shall be the responsibility of the Contractor to determine the appropriate size and location of access doors such that sufficient clearances access is provided to perform the required inspection, maintenance, repair, replacement, etc. of the item requiring access.
33. The Contractor is responsible for the layout of all its own work and for providing all sleeves and inserts at all wall, floor and beam penetrations.
34. The Contractor shall verify the mounting heights, location, and orientation of all finished devices (i.e. thermostats) with the Employer's Representative and Architect prior to their installation. The Contractor shall be responsible for all costs associated the relocation of devices installed incorrectly.
35. The Contractor shall provide all outlets, ports, wells, etc as required to support the work of the BMS / Automatic Temperature Controls Contractor. In some instances information regarding the size and location of such outlets and ports will not be available during the shop drawing stage of the project prior to pipe fabrication. In such instances the Contractor shall perform all related field modifications to "existing" piping as a part of this Contract at no additional charge.
36. The Contractor shall provide and install equipment support stands pre-finished with a corrosion resistant coating (Hot dip Galvanized) for all equipment furnished under this Contract.
37. All supports shall be installed within the confines of the Architectural dimensions, partitions, column enclosures, ceilings, soffits, etc. Should the Contractor fail to adhere to this requirement it shall adjust its work (e.g. relocate supports, etc.) to conform. Any costs to repair damage caused by the Contractor's failure to conform to the above, will be borne by the Contractor.
38. Structural openings in floors, beams and shear walls will be provided by others as indicated on the Structural and/or Architectural drawings. The Contractor shall be responsible for verify-

Copyright © Buro Happold Limited

ing that the size and location of all such openings correlate with the size and locations requirements as indicated on the Mechanical Drawings and as dictated by the coordinated shop drawings prepared by the Contractor. The Contractor shall notify the Employer's Representative immediately of any required hinges to opening locations that result from their review. In the event that the Contractor fails to notify the Employer's Representative of any required changes prior to the fabrication of steel and / or placement of concrete, the implementation of all such changes shall be performed at the Contractor's expense.

39. The Contractor shall submit a BUILDER'S WORK drawing showing the size and location of all required beam , slab, wall penetrations for submittal to the structural engineer. The contactor shall be responsible for verifying that the size and location of all builders work openings correlate with the size and locations requirements as indicated on the Mechanical drawings and as dictated by the coordinated shop drawings prepared by the contactor. If for any reason the builder's work openings /sleeves issued by HVAC contractor are bigger than required, in this case the HVAC contractor shall close those openings at no extra cost.
40. The Contractor shall provide vibration isolation components for all equipment installed under this contract, including equipment furnished by others. Additionally, the Contractor shall provide all structural support steel and/or upper supports, unistrut, channel, angle iron, etc., that is located between equipment and vibration isolators furnished under this Contract.
41. The Contractor shall coordinate the installation of all equipment requiring power with the Electrical Contractor to ensure compatibility with the building power distribution system. All such equipment shall be furnished with detailed point-to-point wiring diagrams.
42. Stand alone motor starters and/or variable speed drives shall be provided by the Contractor for all equipment furnished under this Contract regardless of whether or not the starter is specified. At a minimum all starters shall be combination H-O-A type, or as required to satisfy the specified equipment control functions. (Note that variable frequency drives associated with the per-purchased equipment shall be provided by others only if specifically indicated as such).
43. The Contractor shall provide all variable frequency drives with a communications interface capable of communicating via Modbus or BAC net standard.
44. Thermal overloads, fuses and auxiliary contacts shall be provided for all starters furnished under this Contract. All starters shall be tagged in an approved manner and furnished with sufficient quantities and types of auxiliary contacts for all required connections by others (i.e. BMS, FA, etc.).
45. Overhead protection for the Contractor's personnel working in shafts is the Contractor's responsibility.
46. The Contractor shall provide as applicable to the work of this scope, all labor and Vendor support services necessary to assist the Electrical and Fire Alarm Contractors in pre-testing, testing and demonstration of the fire alarm system, smoke purge system and all local controls as required by the local authorities. The Contractor shall perform the above work outside of normal working hours as required and as directed by the Employer's Representative (regardless of the cause for the overtime requirement).
47. The Contractor shall provide counter-flashing for all work under this Contract.
48. It is understood, the labor to replace warranty parts has been made part of all pre-purchased agreements. This Contractor shall provide any supplemental trade labor required for the performance of this work by pre-purchase equipment suppliers, in the event that disconnect and reconnection of piping, ductwork, trim of any kind, hoisting and scaffolding shall be provided by this Contractor for the stipulated DLP.
49. Any temporary work installed by the Contractor, either before or after coordination, which interferes with this trade's or another trade's ability to install its permanent work, shall be removed and relocated within (24) hours from notification by the Employer's Representative, on an overtime basis if necessary at no additional cost.

Copyright © Buro Happold Limited

50. The Contractor is aware that a formal Building Commissioning Program shall be managed by the Employer's Representative. Accordingly, the Contractor shall be required to formally commission and demonstrate each system and/or system component in accordance with a formal set of testing procedures and protocols prior to the formal turnover and Owner Acceptance of any such systems and/or system components. The Contractor shall provide all project management supervision and labor required to carry out this program in accordance with the Employer's Representative's requirements and as necessary to fully implement the appropriate testing protocols. The Contractor shall be responsible for the completion and submission of all required pre-functional test forms and associated documentation as required prior to equipment startup. Additionally, it shall be the responsibility of the Contractor furnishing equipment to take the lead and obtain all relevant information and pre-functional documentation from all other Contractors whose work is related to such equipment and required on the pre-functional forms.
51. The Contractor shall be responsible for pre-testing all equipment prior to scheduling any demonstration and acceptance testing with the Employer's Representative and Commissioning Agent. The Contractor shall be held responsible for all costs associated with any rescheduling in the event that the scheduled acceptance testing must be cancelled resulting from incomplete work after a pre functional check has been performed. This includes costs associated with the required personnel representing Employer's Representative any other Contractors necessary to support the equipment commissioning related activities.
52. The Contractors with, equipment Vendors Technicians in association with the Electrical and BMS Control Contractor will demonstrate to the Employer's representative the physical response of the systems and compare them to the specified design parameters under load. Contractor shall include all labor costs for connecting any special test equipment and test recording meters. All overtime to perform testing is included where specified testing continues beyond the normal workday. Note: Every check or test, for which accepted performance was not achieved, will be repeated at no additional cost to the Owner, after the necessary corrective measures have been completed and demonstration of acceptable performance is achieved. In addition to the specified equipment unit or component or sub-system testing, provide all support labor with out limitation for integrated testing period in accordance with the Commissioning Authority's testing method of procedures.
53. Within one (1) week of the receipt of a "non-conformance" or"punch-list", the Contractor shall perform all corrective work indicated on the list. Upon receipt of a punch-list," for any given area, the Contractor shall assign a sufficient number of "punch-list teams" to complete the work per the Employer's Representative's scheduling requirements. Any and all costs to repair damages caused by the Contractor during the performance of this, or any other work, shall be charged to the Contractors account.

P. Imported Equipment

The successful tenderer shall submit upon award the following to facilitate the Owner in their application for concessional duty for equipment/material proposed to be directly purchased and imported by them.

1. Four copies of proforma invoice from Manufacturer/Supplier drawn in the name of Owner identifying FOB price from the country of origin and Freight cum Insurance up to site.
2. Four sets of Technical .Literature, high lighting model number and all technical details of the actual equipment/material offered by them.
3. Successful bidder shall indicate packing specification for imported equipment / material.
4. Successful bidder shall furnish undertaking from local agents for all imported equipment that they will provide all technical data & engineering information on the product through their principles, all back-up services during detailed engineering testing and commissioning and service during and after the defects liability period.
5. Computerized equipment selection print outs.

Copyright © Buro Happold Limited

Q. Quiet Operation And Vibration Isolation

All equipment shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Employer's Representative. In case of rotating machinery sound or vibration noticeable outside the room in which it is installed, or annoyingly noticeable inside its own room, shall be considered objectionable. Such conditions shall be corrected by the Contractor at his own expense. The contractor shall guarantee that the equipment installed shall maintain the specified NC levels. In case contractor desires to suggest additional precautions other than those specified in tender, the same shall be incorporated after technical & financial approval of Employer's Representative. However for noise vibration and isolation, specification laid by M/s Cerami associates will superceed all the requirements.

R. Accessibility

The Contractor shall verify the sufficiency of the size of the shaft openings, clearances in cavity walls and suspended ceilings for proper installation of his ducting and piping. His failure to communicate insufficiency of any of the above shall constitute his acceptance of sufficiency of the same**.** The Contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. The exact location and size of all access panels, required for each concealed control damper, valve or other devices requiring attendance, shall be finalized and communicated in sufficient time, to be provided in the normal course of work. Failing this, the Contractor shall make all the necessary repairs and changes at his own expense. Access panel shall be standardized for each piece of equipment / device / accessory and shall be clearly nomenclature / marked and coordinate with other agencies.

It shall be responsibility of HAC contractor to monitor other agency work which may affect the performance of HVAC system. Sealing of all unwanted openings in external walls and partitions shall be identified to Employer's Representative prior to commissioning.

S. Materials And Equipment

All materials and equipment shall conform to the relevant Indian Standards and shall be as per the list of approved makes.

T. Manufacturer's Instructions

Where manufacturer has furnished specific instructions, relating to the material and equipment used in this project, covering points not specifically mentioned in these documents, such instructions shall be followed in all cases.

U. Electrical Installation

The electrical work related to air conditioning services, shall be carried out in full knowledge of, and with the complete coordination of the Electrical contractor. The electrical installation shall be in total conformity with the control wiring drawings prepared by the contractor and approved by the Employer's Representative All air conditioning equipment shall be connected and tested in the presence of an authorized representative of the contractor.

The air conditioning system shall be commissioned only after the contractor has certified in writing that the electrical installation work for air conditioning services has been thoroughly checked, tested and found to be totally satisfactory and in full conformity with the contract Drawings, Specifications and manufacturer's instructions. It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, of the electrical installation work for air conditioning services, lies solely with the contractor**.**

V. Local Authority Approval

On completion of the Electrical installation for air conditioning, a certificate shall be furnished by the contractor, counter signed by the licensed supervisor, under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local authority. The contractor shall be responsible for getting the entire electrical installation for air conditioning system duly approved by the local authorities concerned, and shall bear expenses if any, in connection with the same.

Copyright © Buro Happold Limited

W. Operating Instruction & Maintenance Manual

1. General

Upon completion and commissioning of part HVAC system the contractor shall submit a draft copy of comprehensive operating instructions, maintenance schedule and log sheets for all systems and equipment included in this contract. This shall be supplementary to manufacturer's operating and maintenance manuals. These manuals shall also include basis of design, detailed technical data for each piece of equipment as installed, spare parts manual and recommended spares for 2 year period of maintenance of each equipment. The Contractor shall provide operating instructions and maintenance data books for all equipment and materials furnished under this Division as well as assist the CA in compiling and consolidating O&M information during the development of the site specific Commissioning Plan. The Contractor shall deliver two (2) initial copies of the operation and maintenance manuals in accordance with the subcontractor Scheduling Procedures to the Employer's Representative for review. The initial copies shall contain all the information available at the time of submission.

The Contractor shall thereafter Submit six (3) final copies of operation and maintenance manuals to the Employer's Representative for review at least four (4) weeks after testing & Commissioning. Assemble all data in a completely indexed volume or volumes in three ring binders and identify the size, model and features indicated for each item. The binders shall have the Project Name and Logo printed on the outside of the binders. Re-submittals of these final six (3) copies of the "Final Review" operation and maintenance books and three (3) electronic DVD-ROM recordable rewrite compact disc shall be delivered to the Owner upon Final Completion of the Project.

The contractor shall supply complete operations and maintenance manuals in accordance with the following requirements:

a. The operations and maintenance manual documentations shall be presented in an Avery 3" heavy duty white binder or equivalent at the time of original submission, and record manuals within four weeks of integrated delivery of equipment to the site.
b. The binder shall have a cover page depicting the system(s) covered by the manual, Owners name, site location, and date.
c. The binder shall contain a detailed table of contents page delineating all major sections of the manual. Each section of the manual shall have an Avery narrow tab type divider placed between sections (properly labeled) to ensure easy access. The major sections of the manual shall include:
    i. Manual index
    ii. Specification Section reference number and index.
    iii. Equipment and/or material model number and serial numbers.
    iv. Identifying name, mark number, plan/drawings tagging, etc.
    v. Locations of major equipment (where several similar items are used, provide a list).
    vi. Manufacturer's catalogue literature including model, type, style, complete standard factory operations manual, brand name data, etc.
    vii. Installation manual
    viii. Operations manual
    ix. Maintenance manual with lubrication charts, and recommended periodic maintenance and schedules
    x. Detailed sequences of operation for all operating modes
    xi. Supplier, dealer, distributor, vendor and service organizations including phone, fax and email addresses and name of contact person.
    xii. "Final Review" or approved submittals.
    xiii. Dimensional drawings with equipment weights
    xiv. List of spare parts recommended for normal service requirements.
    xv. List of Spare parts purchased as part of this project,
    xvi. Performance curves and data including part load curves were applicable.

Copyright © Buro Happold Limited

xvii. Wiring and interlock wiring diagrams in both system and ladder formats.
xviii. Motor ratings and actual loads.
xix. Assembly and disassembly instructions with exploded view Drawings where available.
xx. Manufacturer's recommended operation and maintenance instructions with all non applicable information deleted.
xxi. Trouble shooting diagnostic instructions where available.
xxii. Sequences of operation.
xxiii. Copy of all warrantees and guarantees.
xxiv. Copy of all factory and field test reports.
xxv. Completed Functional Test sheets.
xxvi. Completed Pre-functional check lists
xxvii. Copies of all “Data” Sheets
xxviii. Copy of all IGBC LEED™ and GBTC certification documentation where applicable Items required for inclusion in the operations and maintenance manuals that cannot be provided four weeks after delivery of equipment to the site are expected to be submitted within two weeks of completion of the work in a format for insertion into the binder under a pre-fabricated tab that is identified in the table of contents (i.e. The site acceptance test may not be complete at the time this manual is required for submission, in this case the manufacturer shall submit the manual with this section empty, upon completion of the site acceptance testing the forms
for this testing will be supplied (punched for the binder)).
All documents shall be submitted electronically using DVD in a dedicated sleeve within the binder.

2. Special Control System O&M Manual Requirements
   In addition to documentation that may be specified elsewhere, the controls contractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs.

   a. Three hard copies, as well as one disk in latest Word format, of the controls training manuals in a separate manual from the O&M manuals.
   b. Operation and Maintenance Manuals in hard copy as well as one disk in latest Word format, containing:
      - Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
      - Full as-built set of control drawings (refer to Submittal section above for details).
      - Full as-built sequence of operations for each piece of equipment.
      - Full points list. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:
        • Floor
        • Room number
        • Room name
        • Air handling unit ID
        • Reference drawing number
        • Air terminal/Fan Coil unit tag ID
        • Heating and/or cooling valve tag ID
        • Minimum cfm
        • Maximum cfm

Copyright © Buro Happold Limited

• Associated CO2 monitor tag
- Full print out of all schedules and set points after testing and acceptance of the system.
- Full as-built print out of software program.
- Electronic copy on disk of the entire program for this facility.
- Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations. (obtain a disk of as-built and coordination drawings from the mechanical contractors)
- Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
- Control equipment component submittals, parts lists, etc.
- Warranty requirements.
- Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

c. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
   Sequences of operation
   - Control drawings
   - Points lists
   - Controller / module data
   - Thermostats and timers
   - Sensors and DP switches
   - Valves and valve actuators
   - Dampers and damper actuators
   - Program setups (software program printouts)

d. Field checkout sheets and trend logs should be provided to the CA for inclusion in the Commissioning Record Book.

3. Special Tab Documentation Requirements
   The TAB will compile and submit the following with other documentation that may be specified elsewhere in the *Specifications.*
   a. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
   b. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

2.

4. Review And Approvals
   Review of the commissioning related sections of the O&M manuals shall be made by the employer's representative/Commissioning agent.

X. Composite Control Wiring Diagram Requirements

As required by the construction schedule developed by the Employer's Representative, this Contractor, along with all other Division Contractors, shall furnish to the BAS Contractor, the project specific wiring and interlock requirement diagrams from the equipment shop drawings for those items of equipment where there is joint wiring interface responsibility. These wiring and interlock diagrams will be furnished to allow the BMS Contractor to prepare project specific composite control wiring diagrams that will detail how equipment furnished by the multiple Contractors shall be interconnected to provide fully functioning interrelated systems, including the life safety system, for the overall project.

The items for which the wiring and interlock diagrams shall be furnished shall include but not be limited to motors, starters, variable speed drives, motor operated dampers, fan systems, lighting relays and/or contactors for the remote control of or by lighting systems, the Fire Detection,

The wiring diagrams furnished to the BAS Contractor shall indicate those terminals and field devices which will be provided for the use of the BAS Contractor(s) to define the control intercon-

Copyright © Buro Happold Limited

nection to allow the interrelated systems to function as specified and as required by all applicable Codes. The BAS Contractor shall add to these drawings, those connections they will make for the control and/or monitoring of the motors, dampers, and other items of equipment. The completed diagram shall include all line and low voltage wiring between control devices, motor start-stop and/or H-O-A stations, control relays, sensors, controllers, switches, differential pressure switches, the Fire Command Station, the Security System, the Building Management System, etc.
One diagram shall be provided for each item or piece of equipment. Diagrams shall be suitable for insertion in a three-ring -binder. The BAS Contractor shall complete the preparation of the composite control wiring diagrams and shall return them to the appropriate Contractors within six (6) weeks of receiving them. The Contractors shall verify that the wiring added to the drawings is correct and can be accommodated. If necessary, corrections shall be made by the BMS Contractor. This process shall be completed prior to commencement of work on the particular piece of equipment or in the area within which the equipment is located.
The intent of this requirement is that single composite drawings shall be available for each item of equipment indicating the wiring that shall be installed in its entirety including interlocks. Any omissions or errors noticed by the Contractors shall be brought to the attention of the Engineer immediately.
Each conductor termination on the composite wiring diagram shall be suitably identified by a termination number or symbol. In addition, each conductor termination shall be suitably indexed to identify the termination location of the other end of the wire.
All internal wiring of panels (in detail) shall be included in the composite wiring diagram. For such items as motor starters, etc., all jumpers added or removed shall be clearly indicated as being “added" or "removed".
The composite wiring diagrams shall include description of the interlock sequence of operation. The description shall include complete identification of each item shown (relay, motor controller, etc.), and each item's exact operation shall be related to the interlock sequence.
This Contractor and their Subcontractors shall coordinate the work of this Division with the requirements of the work of all other Division Contractors as to the need for terminal strips, etc., required by them to interface with and/or control equipment furnished under this Division.

Y. Handing Over Of System

The contractor shall test the installation during three seasons (summer, Winter & Monsoon) to verify equipment performance and inside conditions. After successful performance and demonstration of result, the defects liability period shall be completed. In case of failure to demonstrate the system in any season, the test shall be repeated in following year and handing over shall be extended accordingly.

Z. Guarantees, Certifications And Defects Liability Period

Contractors and their Manufacturers shall provide a full parts and labor warranty during defects liability period of 02 years from the date of system handover to client. Subcontractor must maintain a local full time service company with 24-hour emergency service capable of responding to service needs within 4 hours. Contractor shall be aware that during the full warranty period as defined above, Manufacturers of pre-purchased equipment are to provide all required periodic and routine service and maintenance. The Manufacturer through the Contractor shall submit a service and maintenance plan for approval by the Owner. The Manufacturer must comply with the requirements of Owner’s Service Contract terms and conditions. When purchase agreements are made the responsibility of this Contractor, all service agreements made part of the initial purchase shall pass directly to the Owner. Full payment to the Manufacturer shall not be made without written authorization from the Owner. All other equipment, systems and related appurtenances shall be the responsibility of the Contractor for warranty. All warranty claims whether for pre-purchased or direct purchased equipment shall be the responsibility of the Contractor.

During the defects liability period, the Contractor shall guarantee the following in a form satisfactory to the Owner:

1. All Work installed will be free from any and all defects in Workmanship and/or materials.

Copyright © Buro Happold Limited

2. All apparatus will develop capacities and performance characteristics specified.
3. The systems shall operate without malfunction.
4. The Contractor shall, without cost to the Owner, remedy any defects within a reasonable time to be specified in notice from the Employer's Representative. In default thereof, the Owner may have such Work done and charge all costs to the Contractor.
5. The start of the Contractor's defects liability period, as defined above, shall have no restrictions on start date and extend for the full period noted.
6. The Contractor shall confer with the Employer's Representative prior to the bid date concerning the Schedule and determine if there is a need to operate any items of equipment or systems for temporary heating and/or cooling or other reasons prior to substantial completion. All required extended DLP costs for equipment, materials and systems shall be included in the Contractor's proposal and clearly designated with a breakout price.

AA. BYE-LAWS

1. The Contractor shall comply with all bye-laws and regulations of local and other statutory authorities having jurisdiction over the works and shall be responsible for the payment of all fees and other charges and giving and receiving of all necessary notices and keeping the Owners Representative informed of the said compliance with the bye-laws, payments made, notices issued and received.
2. The Contractor shall indemnify the Employer's Representative against all claims in respect of patent rights, designs, trade marks or names or other protected rights in respect of any plant, machine, work or material used for or in connection with the works or temporary works and from and against all claims, demands, proceedings, damages, cost, charges and expenses whatsoever in respect thereof or in relation thereto. The Contractor shall defend all actions arising from such claims and shall himself pay all royalties, license fees, damages, costs and charges of all and every sort that may be legally incurred in respect thereof. This charge/fee must be included in the item rate.

BB. DESIGN CONFIRMATION BY TENDERER

A. Tenderer shall confirm that the space provided for various equipment in the tender drawings is adequate to install and maintain all the equipments.

B. If the spaces provided in the tender drawings are inadequate to install the Tenderer's equipment, it shall be clearly indicated in the tender itself.

CC. DESIGN CONFIRMATION BY CONTRACTOR

A. Contractor shall confirm in writing that the design on which this tender is prepared has been verified by them and that it meets with the requirements of all Government. Semi-Government, Municipal and other Authorities, whose permission would become necessary for the completion of the Project.

B. Contractor shall confirm that the design is verified by them and is good enough to maintain the specified design condition as per specifications and drawings.

C. Contractor shall also confirm that in their opinion the design is economical and safe and they have nothing to suggest either by way of effecting further economy or providing additional safety or better performance

DD. Operation And Maintenance

For details of this section , Please refer to GCC & SCC Documents issued for the project.

EE. Operating Instructions And Training

Copyright © Buro Happold Limited

For details of this section , Please refer to GCC & SCC Documents issued for the project.

FF. Partial Ordering

Owner through the Employer's Representative reserves the right to order equipment and material from any and all alternates, and /or to order high side and /or low side equipment and materials or parts thereof from one or more Tenderer's**.**

GG. Soft Water And Power Requirement

The contractor shall allow for factory visits for major equipments for two persons from client side and two persons from consultant side

Sr No	Service	Type	Location of Battery Limit
1	VRV System Electric Supply to ODU	Internal HVAC	Electric isolators near (2m) ODU provided by others. HVAC contractor to extend power from isolator to ODU.
2	VRV System Electric Supply to IDU	Internal HVAC	Electric socket near (2m) IDU provided by others. HVAC contractor to extend power from sockets to IDU.

Copyright © Buro Happold Limited