

TECHNICAL SPECIFICATIONS FOR HVAC WORKS

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

CONTENTS

1. GENERAL NOTES:	5
2. SPECIAL CONDITIONS - HVAC	6
2.1. DRAWINGS	8
2.2. LIST OF SIMILAR INSTALLATIONS & CAPABILITIES	8
2.3. WORKMANSHIP	8
2.4. ACCEPTANCE OF EQUIPMENTS & MATERIALS	9
2.5. TESTING	9
2.6. OPERATING INSTRUCTIONS & TRAINING	9
2.7. STANDARDS	10
2.8. WORKS TO BE DONE BY THE TENDERER	10
2.9. WORKS CARRIED OUT BY OTHER AGENCIES	10
2.10. POST WARRANTY MAINTENANCE	10
2.11. IMPORTED EQUIPMENTS	10
2.12. SUBMITTALS	11
2.13. QUALITY CHECK FORMS	11
2.14. PROJECT MANAGEMENT	11
2.15. SITE FACILITIES/INFRASTRUCTURE	11
2.16. CODES & STANDARDS:	12
2.17. SCOPE OF WORK:	12
2.18. GENERAL:	12
3. VARIABLE REFRIGERANT FLOW SYSTEM	13
3.1. SCOPE	13
3.2. TYPE	13
3.3. OUTDOOR UNIT	13
3.3.1. COMPRESSOR	14
3.3.2. HEAT EXCHANGER	14
3.3.3. REFRIGERANT CIRCUIT	14
3.3.4. SAFETY DEVICES	14
3.4. OIL RECOVERY SYSTEM	15
3.5. ENVIRONMENTALLY AWARE	15
3.6. CENTRALIZED TYPE REMOTE (TOUCH SCREEN TYPE) CONTROLLER	15
3.6.1. UNIFIED ON/OFF CONTROLLER (OPTION IF SPECIFIED IN BOQ)	15
3.6.2. SCHEDULE TIMER	16
3.7. REFRIGERANT PIPING	16
3.8. CODES AND STANDARDS	17
3.9. GENERAL REQUIREMENTS	17
3.9.1. PAINTING	18
3.9.2. REFRIGERANT	18
3.9.3. INSTALLATION AND COMMISSIONING	18
3.10. VRF PERFORMANCE TESTS	19

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

3.11.	HARMONIC FILTERATION	20
3.12.	TECHNICAL REQUIREMENTS	20
4.	DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT	24
	MODE OF MEASUREMENT:	26
	REFRIGERANT PIPING	26
	SCOPE	26
	CODES AND STANDARDS	26
	SCOPE OF SUPPLY AND ERECTION	27
4.1.	MATERIAL SPECIFICATION	27
4.2.	REFRIGERANT PIPING AND FITTINGS	28
4.2.1.	FITTINGS, VALVES AND ACCESSORIES:	29
4.3.	PIPE INSULATION	30
4.4.	DATA TO BE PROVIDED AFTER INSTALLATION	31
	MODE OF MEASUREMENT:	31
	Piping and Pipe insulation	32
5.	CEILING SUSPENDED UNIT	33
5.1.	CASING	33
5.2.	COOLING COIL SECTION	33
5.3.	FILTERS	34
5.4.	FAN	34
6.	EXHAUST FANS & FRESH AIR FAN	35
6.1.	CASING	35
6.2.	FILTER SECTION	35
6.3.	FAN SECTION	35
6.4.	CENTRIFUGAL FAN	36
6.5.	CIRCULAR INLINE FAN	37
6.6.	PROPELLER FAN	37
6.7.	KITCHEN EXHAUST FAN	38
	MISCELLANEOUS	39
7.	PIPE AND VALVE WORKS	39
7.1.	PIPES, JOINTS, VALVES & INSULATION	39
7.2.	CPVC PIPE	40
7.3.	PIPE SUPPORTS	40
8.	DUCTS AND AIR TERMINALS	41
8.1.	DUCTS & SUPPORTS	41
8.2.	CNC MACHINE MADE DUCTS WITH DUCTMATE TYPE FLANGES	41
8.3.	AIR PLENUMS	44
8.4.	FLEXIBLE DUCTS	45
8.5.	VOLUME CONTROL DAMPERS	45
8.6.	FIRE DAMPERS	46
8.7.	GENERAL DETAILS	46
8.8.	AIR TERMINALS	47

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

8.9. TESTING OF EQUIPMENTS, PIPES AND VALVES	49
8.10. INSULATION	50
8.11. DUCT INSULATION	51
8.12. CONTROLS & INSTRUMENTATION	52
8.13. EQUIPMENT SAFETY CONTROLS	52
8.14. CONDENSOR.....	53
9. TESTING & BALANCING OF AIR IN HVAC SYSTEMS	55
9.1. BALANCING OF AIR	55
PART 1 – GENERAL BALANCING PROCEDURE.....	55
PART 2 – PRELIMINARY AIR BALANCING PROCEDURE	56
Fan Rotation:	57
Voltage	58
Current	58
Power Factor	59
Fan and Motor Speed	59
PART 3 – AIR BALANCING PROCEDURES.....	59
PART 4 – AIR BALANCING PROCEDURES	60
INSTRUMENTATION	61

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

1. GENERAL NOTES:

01. The rates quoted shall include all taxes.
02. Tax component to be shown separately in summary.
03. Make of the equipment's along with technical specifications and supporting brochures shall be submitted along with boq in sealed cover.
04. Tender document shall be submitted after filling the data form available in it duly signed.
05. Hard copy of boq duly signed only will be accepted (soft copy will not be considered).

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

2. SPECIAL CONDITIONS - HVAC

1. Tenderer is expected to visit the site before submission of the quotations. He must go through all the drawings and documents and fully acquaint himself with various conditions. No claim at a later date on account of lack knowledge of the site and working conditions will be entertained.
2. Owners/Project Manager/Architects/Consultants reserve the right to call upon any bidder to furnish explanations regarding the calculations and clarifications on any details. They have the right to visit the office of the bidder and the various works carried out by the bidder and all reasonable assistance in this regard shall be afforded by the tenderer.
3. Prices should be for an indivisible works contract basis and rates quoted shall include all royalties, taxes, octroi, entry tax and any other taxes leviable by the Government or local statutory bodies, in effect, and the rates shall be all inclusive and no claim whatsoever will be entertained in this respect. However customs and excise duty shall not be included in the prices.
4. A bill of quantities accompanies the tender documents. It shall be understood that the quantities in the schedule are only approximate and are liable to alterations at the discretion of the Owners/Project Manager/Architects/Consultants.
5. The supplier shall carry out the work under the direction and supervision of the Owners/Project Manager/Architects/Consultants or their representative at the site who shall guide the Project Manager from time to time. The supplier shall intimate the names of his Engineers who would be supervising the construction in line with the requirements as specified in the tender and would be responsible for taking the instructions and carrying out the work.
6. The tenderer is responsible for the due and proper execution of all the works, terms and conditions stipulated under this contract. He must examine the designs and satisfy himself of their feasibility. The responsibility of maintaining the conditions will rest with the supplier.
7. The Owners/Project Manager/Architects/Consultants or their representative at site shall have access to the workshop of the successful supplier so as to assure themselves of the quality of material and workmanship.
8. The Owners/Project Manager/Architects/Consultants decision with regard to the quality of the material and workmanship will be final and binding and any material rejected and not complying with the specifications shall be immediately removed from the site by the Supplier.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

9. The tenderer shall include in his rates all material, labor, tools, plant and equipment and transport which may be required in preparation and entire execution and full completion of the work.

10. In interpreting the specifications, the following order of decreasing importance shall apply:

- a. Schedule of quantities
- b. Particular specifications & Special Conditions
- c. Drawings
- d. General specifications.

In case of discrepancy between the bill of quantities, the specifications and/or the drawings, the Owners/Project Manager/Architects/Consultants shall be the deciding authority as to which shall prevail and their decision shall be final and conclusive.

11. The supplier must take necessary and effective measures and caution to prevent death and injuries to his labourers or to any third party. He is solely responsible for the consequences arising out of deaths or injuries or robbery or any other losses of any sort caused through his carelessness or that of agents, representatives or his labourers. The supplier is bound to pay all compensations including workmen's compensation, ESI, PF, claims etc., in every case for the harm that befalls the owner from the demands, claims and expenses which are caused by his execution of the contract. The successful supplier shall take out Supplier's All Risk (CAR) Insurance policy jointly in the name of the owner and the air-conditioning Supplier and the original policy shall be deposited with the employers. The supplier shall cover in the policy against loss or damage due to any causes such as fire, tempest, floods, earthquake, riots, civil war, and insurrection and against damage by aircraft.

12. Any item which is not covered in the Schedule of Rates, but required to be carried out on site, shall be paid as per the actual cost of materials, labor and tools and plant, plus 15% towards overhead and profit. The rates noted in the schedule of rates will apply for the entire project.

13. The supplier shall guarantee that all equipment's shall be free from defect due to defective materials and bad workmanship and that the equipment shall operate satisfactorily and the performance and efficiencies of the equipment shall not be less than the guaranteed values. The guarantee shall be valid for a period of 18 months after taking over and any parts found defective shall be replaced free of cost by the supplier. This period shall be known as defects liability period and shall be reckoned from the date the consultants certify the plant taking over as laid down in the tender conditions. The services of the air-conditioning supplier's personnel if requested during this period for such work shall be made available free of any cost. If defects are not remedied within a month of their occurrence, Owners may proceed to do as to the supplier's expenses, to be mutually agreed upon, without prejudice to any other rights.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

2.1. DRAWINGS

14. The drawings furnished to the tenderer shall be interpreted by the use of given dimension and nomenclature only; they shall not be scaled under any circumstances. Drawings to a large scale have precedence over those to a smaller scale. These drawings are general in nature and cannot be regarded as working drawings.
15. The equipment offered shall be accommodated within the space provided. If additional space is required for the equipment offered by the tenderers, they shall bring out this point clearly in the tender itself. They shall note that claims for additional space at a later stage will not be entertained.
16. Space allocated for major air-conditioning equipment shall be taken into consideration before ordering the equipment and they shall fit into the space provided with required clearances all round as per relevant regulations.
17. The drawings attached to these specifications are general in nature and cannot be regarded as working drawings. The supplier shall prepare his own detailed working drawings and get them approved by Owners/Consultant before execution. Prior to submission for approval, the supplier shall be responsible for thoroughly checking all drawings to ensure that they comply with the intent and the requirements of the contract specifications and that they fit in with the overall building layout.
18. After installation is completed, 6 sets of "As built drawings" shall be prepared in full incorporating all the changes and submitted to Owners/ Consultants along with 2 sets of soft copies on CDs within 1 month of the date of completion of installation.

2.2. LIST OF SIMILAR INSTALLATIONS & CAPABILITIES

19. The tenderer shall bring out specifically in the tender about his set up available in Nimli, Rajasthan for execution of the job. He shall bring out the list of installations of similar jobs carried out. He shall also identify the Engineer who will be assigned for the execution of the job. The Engineers proposed by the supplier has to be formally accepted by the Owners/Project Manager/Architects/Consultants.

2.3. WORKMANSHIP

20. Specific emphasis is made as far as the quality of the workmanship is concerned. The successful supplier has to co-ordinate properly with the Owners / consultants for ensuring the best workmanship. In case the quality of the work of the supplier is not acceptable to the Owners/Project Manager/Architects/Consultants the same shall be redone to the utmost satisfaction of the Owners

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

/ Consultants, failing which Consultants have the liberty to get the job executed on his own/or through other agencies and the supplier will be debited accordingly.

2.4. ACCEPTANCE OF EQUIPMENTS & MATERIALS

21. The major equipment's proposed by the tenderer should have proved its performance at least for a period of one year satisfactorily elsewhere. The Owners/ Consultants have the liberty to acquire more data to ascertain the performance of the equipment for which the supplier has to render reasonable assistance. The decision of accepting or rejecting the equipment's/materials will rest with the Project Manager/Owners/Project Manager/Architects/Consultants.
22. In case the tenderer is proposing an alternate make of equipment's and materials, he should bring out the salient features and advantages of such items over the proposed make of equipment's / materials. The decision of the Owners/Consultant in this regard is final and binding.

2.5. TESTING

23. After manufacture of the equipment, all the necessary routine tests shall be carried out as per the relevant standards listed in the Particular specifications. Routine and type tests for the various items of equipment shall be performed at the supplier's/manufacturer's works and test certificates shall be furnished. The Owners/consultant may depute their authorized representatives to be present during these tests if they desire to do so. The supplier shall provide all test equipment, labor and other service required for these tests free of cost.
24. On completion of the installation the supplier shall conduct under the direction of Owners/Project Manager/Architects/Consultants and in the presence of the Owners and Consultant or their representatives perform tests on the plant as per the "Testing Procedures" in the Particular specifications. In the event full load due to appliances/product load as specified in the design data is not available and/or if the date of test does not coincide with peak summer or monsoon or winter conditions as the case may be, the supplier shall nevertheless conduct tests in the prevailing conditions both shall also repeat them as and when full load due to appliances materializes and during the peak seasons during the Defect Liability period. During such tests the plant shall be kept running continuously for a period of 48 hours. In case the performance does not meet the full intent of the specifications and further tests are considered necessary, the supplier shall bear all expenses thereof.

2.6. OPERATING INSTRUCTIONS & TRAINING

25. The supplier shall furnish a neatly typed set of operating instructions securely framed. These instructions shall include information and guidance on operating pressures, temperatures, air

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

quantities etc. The supplier shall submit 2 copies of operating and maintenance manuals. Such manuals shall include the equipment catalogues, technical details as per the formats in the tender, wiring diagrams, list of spare parts, part numbers and other relevant information.

26. The supplier shall train the Owner's operating and maintenance staff in the operation, repairs and maintenance procedures during installation and maintenance period. Routine operation of the plant for a period of 30 days after handing over the plant shall be done by the Supplier along with the Owner's operating staff. Supplier has to impart training during planning, installation, testing and commissioning of the plant also.

2.7. STANDARDS

27. Wherever reference has been made to various standards in the particular specifications, the latest version of the same at the time of tendering shall be applicable.

2.8. WORKS TO BE DONE BY THE TENDERER

28. The tenderer shall include the following works along with the other works mentioned in the tender:
- All foundation bolts, vibration isolation pads, etc. for the equipment.
 - Any other works connected with air conditioning which is deemed to have been included in the scope of this contract for ensuring satisfactory performance of the plant.

2.9. WORKS CARRIED OUT BY OTHER AGENCIES

- Electrical Panels, cabling and earthing.
- Civil works such as construction of AHU rooms, foundation for equipment, making openings for entry of pipes, ducts etc. However, detailed drawings shall be furnished by the supplier as required at the stipulated time.

2.10. POST WARRANTY MAINTENANCE

29. Tenderers shall quote separately for post warranty maintenance of the air-conditioning system on a comprehensive basis inclusive of materials and labour. They shall also quote alternatively only on labor basis in case the spares are provided by Project Manager. They shall indicate the list of spares to be arranged by the Project Manager in this regard.

2.11. IMPORTED EQUIPMENTS

30. Tenderers are required to note that forms regarding concessional/ nil excise/customs duty will be provided by the owners. As such the tenderers are required not to include the excise duty/customs

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

duty in their offer. However they shall indicate separately the quantum of excise duty/customs duty applicable. Tenderers who are offering imported equipment's are also required to exclude the customs duty in their quotation, but shall indicate the quantum of customs duty applicable and the exchange rate of the currency considered in their offer. The tenderers are required to include along with the imported equipment's, their rates for clearing the consignment till site including freight, insurance, installation, testing and commissioning charges in Indian Rupees. No L.C will be opened by Owners and only 100% wire transfer on receipt of materials at site is applicable. The successful supplier has to provide all assistance to the Owners and submit the required documents and clear the consignments on behalf of the Owners.

2.12. SUBMITTALS

31. The successful supplier shall prepare the technical submittals for approval before ordering the materials. It is likely that such submittals may change the makes of certain equipments/items even though the same was proposed by the supplier during the tender stage, when such items do not comply fully with the specifications and requirements. No escalation in price is feasible under such circumstances. Samples and catalogues highlighting the equipments and materials shall accompany the submittals. Technical submittals shall bring out clearly the deviations to the tender specifications. The approval of the technical submittals rests with the Owners/Project Manager/Architects/Consultants.

2.13. QUALITY CHECK FORMS

The successful contractor shall submit to the consultants/owners on daily basis the quality control check forms duly filled in. Erection shall be considered complete only if stage-wise quality inspection is completed in all aspects. The contractor shall take the instructions from Consultants and Owners and strictly comply with the same.

2.14. PROJECT MANAGEMENT

The successful contractor shall monitor the project on daily basis using advanced project management techniques.

2.15. SITE FACILITIES/INFRASTRUCTURE

Successful contractor shall employ the committed accepted manpower at site all times. Non availability of the required manpower from the contractor's part justifying the lesser manpower is not acceptable and will result in serious default of the conditions of the contract. The manpower committed shall not be changed or withdrawn without the prior approval of the Owners /

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Consultants. The site office shall have independent telephone/cell phone/pager for the Site In charge. The site office shall have all the required documents such as contract, agreement and drawings. The contractor shall have the following personnel on full time basis at the site:

Project Manager – 1 No -Graduate in Engineering with minimum 8 years experience

Project Engineers–2 Nos –Graduate in Engineering with minimum 4 years experience

Site supervisors – 2 nos. – Diploma in Engineering with minimum 3 years experience.

2.16. CODES & STANDARDS:

The design, materials, manufacture, inspection, testing and performance of Liquid Chilling Package units shall comply with all currently applicable statues, regulations, codes, and standards in the locality where the equipment is to be installed. Nothing in this specification shall be construed to relieve the tenderer of this responsibility.

The Liquid Chilling Package units shall be made according to the guidelines of latest editions of EUROVENT, ARI, ASHRAE, ISHRAE and other applicable standards.

2.17. SCOPE OF WORK:

The scope of this section comprises the supply, erection, testing and commissioning of Air-Cooled Screw Chiller machine confirming to following specifications and in accordance with the requirement of Drawings and of Schedule of Quantities.

2.18. GENERAL:

The Air cooled machine shall consist of Variable VI inverter-driven compressor Screw compressors, squirrel cage induction motor, starter, Electronic Expansion Valve, Shell & Tube heat exchanger- Evaporator and **air cooled condenser with Copper – Aluminum Condenser Coil Required ,Microchannel OR all Aluminum Coil shall not be acceptable** .Axial fans and with filled R134 A .Refrigerant piping, wiring and automatic controls all mounted on a common steel frame, factory charged refrigerant gas and oil, spring isolator and other accessories factory assembled and tested. Machine shall be designed for tropical climate & multiple start-ups.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

3. VARIABLE REFRIGERANT FLOW SYSTEM

3.1. SCOPE

The scope of this section comprises the supply, erection testing and commissioning of Variable Refrigerant Volume System conforming to these specifications and in accordance with the requirements of Drawing and Schedule of Quantities.

3.2. TYPE

Units shall be air cooled, variable refrigerant volume air conditioner consisting of one Outdoor unit and multiple indoor units. Each indoor units having capability to cool Independently for the requirement of the rooms.

It shall be possible to connect multiple indoor units on one refrigerant circuit. The indoor units on any circuit can be of different type and also controlled individually. Following type of indoor units shall be connected to the system:

- Wall mounted type Hi wall
- Standard Cassette unit
- Split type Ductable unit

Compressor installed in outdoor unit shall be equipped with at least one inverter compressor.

Up to 8HP and 5HP. The system shall be capable of changing the rotating speed of inverter.

Compressor by inverter controller in proportion to variations in cooling load.

Outdoor unit shall be suitable for mix match connection of all type of indoor units.

The refrigerant piping between indoor units and outdoor unit shall be extended up to 150m with maximum 50m level difference **without any oil traps.**

Both indoor units and outdoor unit shall be factory assembled, tested and outdoor units filled with first charge of refrigerant before delivering at site.

3.3. OUTDOOR UNIT

The outdoor unit shall be factory assembled, weather proof casing, constructed from heavy gauge mild steel panels and coated with baked enamel finish. The unit should be completely factory wired tested with all necessary controls and switch gears:

- The unit should be provided with duty cycling for automatically switching starting sequence of multiple outdoor units/compressors.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

- The noise level shall not be more than 60-65 dB (A) at normal operation measured horizontally 1m away from the unit.
- The outdoor unit shall be modular in design and should be allowed for side by side installation
- The unit shall be provided with its own microprocessor control panel.

The outdoor unit should be fitted with low noise, aero spiral design fan with large airflow and should be designed to operate compressor-linking technology.

The condensing unit shall be designed to operate safely when connected to multiple fan coil units, which have a combined operating nominal capacity up to 130 % of indoor units.

3.3.1.COMPRESSOR

The compressor shall be highly efficient scroll type operating on R410a/or better environmentally friendly refrigerant and capable of inverter control. It shall change the speed in accordance to the variation in cooling load requirement:

- The inverter shall be IGBT type for efficient and quiet operation.
- All outdoor units shall be designed for automatic capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated stock. Forced lubrication may also be employed.
- Oil heater shall be provided in the compressor casing.

*: IGBT represents Insulated Gate Bipolar Transistor.

3.3.2.HEAT EXCHANGER

The e-Pass heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil.

- The aluminium fins shall be provided with special coating.
- The unit shall be provided with necessary number of direct driven low noise level propeller type aero spiral fans with DC motor arranged for vertical discharge. Each fan shall have an Aero fitting grille resulting in reduced pressure loss.

3.3.3.REFRIGERANT CIRCUIT

The refrigerant circuit shall include liquid & gas shut-off valves and a solenoid valves at condenser end. All necessary safety devices shall be provided to ensure the safely operation of the system.

3.3.4.SAFETY DEVICES

All necessary safety devices shall be provided to ensure safe operation of the system.

Following safety devices shall be part of outdoor unit; high pressure switch, fuse, crankcase heater, fusible plug, over load relay, protection for inverter, and short recycling guard timer.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

3.4. OIL RECOVERY SYSTEM

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigeration piping lengths.

3.5. ENVIRONMENTALLY AWARE

R410A/Or better is a new mixed refrigerant that exhibits superior safety characteristics. Even with zero coefficient of ozone layer depletion; R410A/Or better offers a better performance to the conventional R22.

Further lead free PC Boards making its use even more environmentally conscious.

Galbarium, a material that requires no coating, is used for the bottom plate for easy recycling.

3.6. CENTRALIZED TYPE REMOTE (TOUCH SCREEN TYPE) CONTROLLER

A multifunctional compact centralized controller shall be provided with the system.

The Graphic Controller must act as an advanced air conditioning management system to give complete control of VRV air conditioning Equipment, It should have ease of use for the user through its touch screen, icon display and color LCD display.

It shall be able to control up to 64 groups of indoor units with the following Functions: -

- a) Starting/stopping of Air-conditioners as a zone or group or individual unit.
- b) Temperature settling for each indoor unit or zone.
- c) Switching between temperature controls modes, switching of fan speed and direction of airflow, enabling/disabling of individual remote controller operation.
- d) Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, and troubleshooting information.
- e) Display of air conditioner operation history.
- f) Daily management automation through yearly schedule function with possibility of various schedules.

The controller shall have wide screen user friendly color LCD display and can be wired by a non polar 2 wire transmission cable to a distance of 1 km. away from indoor unit.

3.6.1. UNIFIED ON/OFF CONTROLLER (OPTION IF SPECIFIED IN BOQ)

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Unified ON/OFF controller shall be supplied as optional accessory. The controller shall be able to control minimum 15 groups (each group containing maximum 16 indoor units) or 128 nos. of indoor units with the following functions:

- a) On/Off as a zone or individual unit.
- b) Indication of operation condition of each group.
- c) Select one of 4 operation modes.

3.6.2.SCHEDULE TIMER

A schedule timer shall be supplied as an accessory.

- a) The timer shall be able to set operation schedule for all indoor units.
- b) The timer shall be able to set 8 pattern of schedule combined with centralized controller.

3.7. REFRIGERANT PIPING

All refrigerant piping for the air conditioning system shall be constructed from hard drawn copper refrigerant pipes for all pipe sizes with copper fittings and silver-soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before joining any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints through nitrogen bleeding at 1.0kg/sq.cm and subsequently, it shall be thoroughly blown out using nitrogen.

After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 30Kg per sq.cm. Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum if 700mm hg.

The air-conditioning system supplier shall be design sizes and erect proper interconnections of the complete refrigerant circuit.

The thickness of copper piping shall not be less than 20gauge for pipes up to 19.1mm and 18gauge for bigger sizes.

The suction line pipe size and the liquid line pipe size shall be selected according to the manufacturers specified outside diameter. All refrigerant pipes shall be properly supported and anchored to the building structure using steel hangers, anchors, brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the load imposed thereon.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

To protect nitrile rubber insulation of exposed copper piping from degrading due ultra violet rays & atmospheric condition, it shall be covered polyshield coating with at least two coats of resin and hardener above nitrile rubber insulation.

Same to be covered with M.S Type / G.I.Type protection tray.

3.8. CODES AND STANDARDS

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

ASHRAE 15	Safety Code for Mechanical Refrigeration
ASHRAE 23	Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units
ASHRAE 30	Methods of Testing Liquid Chilling Packages
ASME SEC. VIII DIV. 1	Boiler and Pressure Vessel Code
ANSI B 31.5	Code for Refrigeration Piping

3.9. GENERAL REQUIREMENTS

Each chilling package shall be complete assembly of all components viz. electric motor driven semi-hermetic or hermetic screw compressor, VRV, condenser, refrigerant piping, oil cooler, protective devices, microprocessor control panel, unit mounted solid state starter and local electrical panel, etc. mounted on a common structural frame.

****Performance will be in accordance with ARI Standard 550/590. ****

All rotating parts shall be statically and dynamically balanced.

In addition to the features specified, if the chilling package requires any additional features for safe and efficient operation, the same shall be included in the scope of supply and shall be clearly indicated and described.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Requirement of refrigerant, oil and other consumables shall be provided by the contractor till the plant is taken over by the EMPLOYER.

The chilling package shall be dispatched to site in fully assembled and factory tested condition with the full refrigerant and oil charge.

The entire water cooled screw VRV package shall be imported, as a fully assembled and factory tested unit. Import of the VRV package in disassembled condition, or in CKD form is not acceptable.

3.9.1. PAINTING

Painting shall be as per standard.

3.9.2. REFRIGERANT

The VRV shall utilize Refrigerant R-410A/Better.

3.9.3. INSTALLATION AND COMMISSIONING

Supervision of the positioning on plinths, pressure testing, evacuation, dehydration charging and the initial start up shall be by factory trained representatives of the equipment manufacturer, who have had extensive experience with the particular type of machine being installed.

This representative shall start up the equipment, adjust and calibrate controls and rectify any faults which may be found. Concurrently he shall fully instruct the personnel's who will later be in charge of the operation and maintenance of the plant.

This representative shall remain on site a minimum time of 15 days consecutive working days. Should the liquid VRVs be found not working satisfactorily by the end of this period this representative shall remain on site until in the opinion of the Consultant/Client the VRVs are operating satisfactorily?

The liquid VRVs and their components shall be given the following tests and such other tests as the Consultant/ Client considers necessary to bring the equipment into running order.

(a) Evacuation of Liquid VRVs

The refrigeration system shall be evacuated by means of a suitable vacuum pump to a pressure of not greater than 0.7kPa (0.1 psi) after which it shall be closed off and left to stand for 24 hours.

(b) VRV capacity

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

An approximate check of total refrigeration capacity of the VRV machines shall be carried out if climatic conditions. Permit.

(c) Commissioning Tests.

While the manufacturer's technician is on site the contractor shall arrange the commissioning tests to be carried out and witnessed by the Consultant Engineer. The commissioning tests shall involve a complete check of the operation of all parts and safety controls associated with the chilled water machines, including associated pumps, auto start/stop controls, electrical supply and starter, cooling tower and any associated alarm control system.

The commissioning check of the VRV shall include check of evacuation, refrigerant and oil charge, electrical starter and associated control functions, motor windings, thermistor strips, bearings, water flow quantities, flow switch functions, purge unit functions, pump out unit functions, electrical wiring interlocks, refrigeration HP/LP controls, refrigeration low temperature thermostat, low oil pressure cut-out, oil level safety cut-out, high discharge temperature safety cut-out, leaving water thermostat and control, load limit controller, functions, recycle timer/programmer functions, and then a check of running pressures, temperatures, fluid levels, amps, motor overload trip settings to establish that proper operation is achieved.

3.10. VRF PERFORMANCE TESTS

To ensure quality, guaranteed efficiency and performance in compliance with the Specified conditions, at least one unit of each model of the package liquid VRV shall be fully tested.

The tests shall be conducted at the manufacturer's factory or workshop where proper testing facilities are available and the test results shall be submitted to the Consultant Engineer upon delivery of VRV. The design ambient condition should be simulated during the VRV performance test.

The contractor shall be responsible for the arrangement of the tests and all expenses Incurred for two Engineers including business class air travel, 5 star accommodation and all other expenses.

After assembly and pressure testing the VRV SYSTEM shall be tested on the following (in accordance with ARI whenever applicable)

- Full load capacity.
- Capacity control range as specified and stability of operation at minimum load.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

- Efficiency at full load and partial load. Readings of VRV performance at 100% 80% 70% 60% 50% and minimum loadings are required.
- Safety device activation.
- Pressure drop across evaporator and condenser.
- Noise levels at various points.
- Vibration levels at various points.
- The contractor shall submit the test schedule at least one (1) month before the proposed date of testing.

3.11. HARMONIC FILTRATION

The VRVs/VRV switch board shall be equipped without harmonic filtration.

3.12. TECHNICAL REQUIREMENTS

Sl. No.	General Description		Requirement
1	NUMBER REQUIRED	:	2 (WORKING)
2	LOCATION	:	OUTDOOR
3	DUTY		CONTINUOUS (12Hrs/DAY)
4	CAPACITY REQUIRED AT SPECIFIED DESIGN CONDITIONS PER CHILLING PACKAGE		AS per BOQ
5	REFRIGERANT		R 134 a/R-410a
6	MAXIMUM IKW/TR AT FULL LOAD		1.1
7	MAXIMUM NOISE LEVEL AT A DISTANCE OF 1.5 METRES		55 dB(A)
8	COMPRESSOR		
8.1	TYPE		
8.2	SEMI-HERMETIC / HERMETIC		ACCEPTABLE
8.3	SINGLE SCREW / DOUBLE SCREW		ACCEPTABLE
8.4	DRIVE : DIRECT / GEAR		ACCEPTABLE
8.5	DRIVE GUARD :		REQUIRED
9	LUBRICATION:FORCED FEED WITH AN OIL PUMP/DIFFERENTIAL PRESSURE		REQUIRED

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

10	CAPACITY CONTROL : AUTOMATIC –10% TO 100% CAPACITY	REQUIRED
11	STATIC AND DYNAMIC BALANCING OF SCREWS : AS PER ISO 1940	REQUIRED
12	HEAT EXCHANGER	
13	TYPE : FINNED TYPE DX	ACCEPTABLE
14	MOTOR	415V, 3 PHASE, 50 Hz
15	MICRO-PROCESSOR CONTROL PANEL	REQUIRED
16	CONTROL PANEL TO BE INTERFACED WITH BUILDING AUTOMATION SYSTEM	YES

NOTE: The contractor in his quote shall include the expenses of 2 people for 5 working days inclusive of all travel, hotel and other expenses for testing of VRVs at the manufacturer's works.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

DATA SHEET – B

DATA TO BE FURNISHED BY TENDERER ALONG WITH OFFER

SI. No.	ITEM DESCRIPTION	UNIT	CONTRACTOR'S INPUT
1.	VRV type	-	
2.	Quantity – Working / Stand by	No	
3.	Tag Numbers	-	
4.	Location	-	
5.	Place of manufacture		
6.	Model number and make		
7.	Minimum Refrigeration capacity	TR	
8.	Type of Compressor and speed	rpm	
9.	Design chilled water flow rate	M ³ / hr	
10.	Maximum chilled water pressure drop	MLC	
11.	Equipment EER		
12.	Refrigerant Charge	Kg	
13.	Fouling factor for VRV OUTDOOR UNIT		
14.	IKW / TR at full load based on 6.7 °C leaving chilled water temperature and 29.5 °C entering condenser water temperature		
15.	Fouling factor for condenser		
16.	Type of starter		
17.	Motor Voltage		
18.	Type of capacity control		
19.	Noise level at 1.86m distance	DB (A)	
20.	Equipment size	(L x B x H)	
21.	Equipment operating weight	Kg	
22.	Full refrigerant charge	Kg	
23.	KW rating (total) of package	KW	
24.	Rated full load amps	RLA	
25.	Maximum inrush current	A	
26.	Computerised printout (certified) from VRV Sub-contractor indicating power consumption in IKW / TR at full load and various part load conditions as per ARI format.		

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

DATA SHEET – B

DATA TO BE FURNISHED BY TENDERER ALONG WITH OFFER

Sl. No.	ITEM DESCRIPTION	UNIT	CONTRACTOR'S INPUT
27.	ARI certification	Yes / No	
28.	Minimum tube removal space required on either end of condenser	mm	
29.	Minimum service space required		
A	Front	mm	
B	Back	mm	
C	Sides	mm	
30.	Type of Vibration Isolators		
31.	Minimum overhead clearance required for installation and service	mm	

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

4. DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACT

- Quality Assurance Plan (QAP).
- Dimensioned general arrangement drawing showing all accessories, mounting details, nozzle locations, etc. for the Heat Pump VRV out door DX package.
- Overall space and head room requirement with details of handling during erection, operation and maintenance.
- Foundation drawing with static and dynamic loading data, pocket details, foundation outline, etc.
- Cross-sectional drawings of all items with part list and materials of construction.
- Power wiring and control wiring diagrams.
- Operation and maintenance manual.

DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION (VARIABLE REFRIGERANT FLOW)

	Description	Unit	Time			Date			Remarks
	COMPRESSOR		10.00	16.00	22.00	10.00	16.00	22.00	
a.	Suction pressure	Kg/cm ²							
b.	Discharge pressure	Kg/cm ²							
c.	Oil pressure	Kg/cm ²							
d.	Suction temperature	°C							
e.	Condensing temperature	°C							
f.	Starting current	Amps							
g.	Consumed current	Amps							
	Heat Exchanger								
a.	Pressure at inlet	Kg/cm ²							
b.	Pressure at outlet	Kg/cm ²							

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

(VARIABLE REFRIGERANT FLOW)

	Description	Unit	Time			Date			Remarks
	COOLER								
a.	Refrigerant temperature at inlet	°C							
b.	Refrigerant temperature at outlet	°C							
c.	Pressure at inlet	Kg/cm ²							
d.	Pressure at outlet	Kg/cm ²							
	SAFETY CHECKS								
a.	High oil pressure	N: Kg/cm ² A: Kg/cm ²							
b.	High compressor discharge pressure	N: Kg/cm ² A: Kg/cm ²							
c.	Low evaporator pressure	N: Kg/cm ² A: Kg/cm ²							
g.	Power fault								
h.	No. of compressors in operation								
i.	Total hours of operation								
j.	Hours since last start								
k.	Any fault history								
l.	No Refrigerant Leaks								

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

(VARIABLE REFRIGERANT FLOW)

	Description	Unit	Time			Date			Remarks
m.	Purge Cycle normal								
n.	Waste Oil, Refrigerant properly disposed of and spare refrigerant properly stored								
o.	Any condensation problems								

MODE OF MEASUREMENT:

Representatives from the Contractor and Engineer shall conduct a joint inspection of the Equipment's. All the discrepancies observed either incomplete works or defective work shall be clearly indicated in the joint inspection report. The mode of measurements given below is for the purpose of measurement and payment and the scope of works shall be as specified elsewhere in the specification.

REFRIGERANT PIPING

SCOPE

This section lays down the general requirements for Supply, Installation and testing of all Piping works like Refrigerant piping Condensate drain piping and related valves and accessories.

CODES AND STANDARDS

The material construction, manufacture, inspection, testing and commissioning of Refrigerant piping shall comply with all currently applicable statutes, regulations and safety codes in the locality where the Equipment will be installed. Nothing in these specifications shall construe to relieve the CONTRACTOR of his responsibility. The equipment supplied shall comply with the latest applicable Indian and / or British Standards. Other National Standards are acceptable, if they are established to be equal or superior.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

SCOPE OF SUPPLY AND ERECTION

The CONTRACTOR shall supply all piping material like pipes, fittings, flanges and other items as required.

Scope of erection to be performed by the CONTRACTOR is outlined below:

- a) The CONTRACTOR shall unload from carriers at plant site, handle, and check, receive, transport, store, erect and test all materials furnished by him and others in accordance with this specification and General Conditions of Contract. The EMPLOYER shall be informed of any loss of damage within seven days of receipt of material.
- b) The CONTRACTOR shall also install small accessory piping and any specialities furnished for equipment such as relief valves, built-in bypass and other equipments of this type.
- c) The CONTRACTOR shall install primary elements for flow measurements, control valves and on-line metering equipment.
- d) The CONTRACTOR shall hydrostatically test the entire piping system including valves and specialities.
- e) All piping shall be internally cleaned and flushed by the CONTRACTOR before and after erection in a manner suited to the service as directed by the EMPLOYER.
- f) For hydrostatic testing and Refrigerant flushing, the CONTRACTOR shall furnish necessary pumps, equipment and instruments, piping etc. The EMPLOYER will provide Refrigerant at available points of supply to which the CONTRACTOR's temporary piping will be connected.
- g) The CONTRACTOR's scope under this includes the following:
 - i) Welding materials like welding electrodes, gas rods, oxygen, acetylene, propane and other consumable materials and backing rings etc., as required.
 - ii) Jointing material as required for all screwed joints. Fasteners (bolts, nuts, studs washers etc.) and gaskets is required for all flanged joints.
 - iii) Services of erection superintendents, erection superiors, fitters, riggers, other skilled and unskilled labour.
 - i) Erection tools, tackles and materials including welding machines.

4.1. MATERIAL SPECIFICATION

- The material specification for piping, valves & specialties shall be as explained in later

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

sections.

- Colour code shall be used to identify pipe material. The Contractor shall be able to identify on request all random piping prior to any field fabrication.
- The Contractor shall furnish six (6) copies of certificates for piping for –
 - a) Dimensions and
 - b) Hydrostatic test

The test pressures shall be as under:

Refrigerant	High Pressure side Kg/sq-cm (psi)	Low Pressure side kg/sq-cm (psi)
R134A	24.5 (350)	10.5 (150)
R410A	24.5 (350)	12.5 (175)

4.2. REFRIGERANT PIPING AND FITTINGS

All refrigerant piping for the air conditioning system shall be constructed from hard drawn copper refrigerant pipes for all pipe sizes with copper fittings and silver-soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air conditioning industry, and are to include charging connections, suction line insulation and all other items normally forming part of proper refrigerant circuits.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before joining any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints through nitrogen bleeding at 1.0kg/sq.cm and subsequently, it shall be thoroughly blown out using nitrogen.

After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 30Kg per sq.cm. Pressure shall be maintained in the system for 24 hours. The system shall then be evacuated to minimum vacuum if 700mm hg.

The air-conditioning system supplier shall be design sizes and erect proper interconnections of the complete refrigerant circuit.

The thickness of copper piping shall not be less than 20gauge for pipes up to 19.1mm and 18gauge for bigger sizes

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

The suction line pipe size and the liquid line pipe size shall be selected according to the manufacturers specified outside diameter. All refrigerant pipes shall be properly supported and anchored to the building structure using steel hangers, anchors, brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the load imposed thereon.

To protect nitrile rubber insulation of exposed copper piping from degrading due ultra violet rays & atmospheric condition, it shall be covered polyshield coating with at least two coats of resin and hardener above nitrile rubber insulation.

Same to be covered with M.S Type / G.I.Type protection tray.

4.2.1. FITTINGS, VALVES AND ACCESSORIES:

1. **Solder joints:** Wrought copper fittings, ASME B16.22.
 - a. Solder, refrigerant tubing: Cadmium free, AWS A5.8/A5.8M, 45 percent silver brazing alloy, Class BAg-5.
 - b. Solder, Refrigerant and drain: 95-5 tin-antimony, ASTM B32 (95TA).
2. **Flanges and flanged fittings:** ASME B16.24.
3. Refrigeration Valves:
 - a. **Stop Valves:** Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, backseating.
 - b. **Pressure Relief Valves:** Comply with ASME Boiler and Pressure Vessel Code; UL listed. Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.
 - c. **Solenoid Valves:** Comply with ARI 760 and UL 429, UL-listed, two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location and normally // open // closed // holding coil.
 - d. **Thermostatic Expansion Valves:** Comply with ARI 750. Brass body with stainless-steel or non-corrosive non ferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

5. **Refrigerant Moisture/Liquid Indicators:** Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.

6. **Refrigerant Filter-Dryers:** UL listed, angle or in-line type, as shown on drawings. Conform to ARI Standard 730 and ASHRAE Standard 63.1. Heavy gage steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.

Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

Liquid-Suction Heat Exchanger: Designed for counter flow and for free drainage of oil. Size shall suit system conditions and refrigerant used. Interchangers shall be ASME construction or UL listed.

4.3. PIPE INSULATION

a. Refrigerant Pipe Insulation

The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, etc. shall be insulated with 19mm /13 mm thick elastomeric nitrile rubber as specified in BOQ.

b. PVC Drain Pipe Insulation

Drain pipes carrying condensate water shall be insulated with 6 mm thick elastomeric nitrile rubber insulation.

For proper drainage of condensate, U Trap shall be provided in the drain piping (wherever required). All pipe supports shall be of pre fabricated & pre painted slotted angle supports, properly installed with clamps etc.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

4.4. DATA TO BE PROVIDED AFTER INSTALLATION

Sl. No.	Description	Unit	Remarks
1.	Hydrostatic pressure conducted as per specification		
2.	Any leaks		
3.	Any defects in joints		
4.	Tested after rectifying defects		
5.	Test witnessed and certified		
6.	Any noise in piping system		
7.	Proper Refrigerant flow achieved through AHU, FCU		
8.	Piping insulation checked		
9.	All valves open		
10.	Expansion joints provided and checked		
11.	Pipe work cleaned		
12.	All strainers clean		
13.	Pressure gauges working		
14.	Thermometers working		
15.	Drain points provided at Low points		
16.	Air vents provided at High points		
17.	Pipe support and spacing checked		
18.	Pipe material checked		

MODE OF MEASUREMENT:

Representatives from the Contractor and Engineer shall conduct a joint inspection of the Equipments. All the discrepancies observed either incomplete works or defective work shall be clearly indicated in the joint inspection report. The mode of measurements given below is for the purpose of measurement and payment and the scope of works shall be as specified elsewhere in the specification.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Piping and Pipe insulation

All Refrigerant pipes and other pipes be measured nett length and measured linear over all fittings such as bends junction etc., and given in running metres. The length shall be taken along -With centre lines of the pipes and fittings. The unit rate shall include fittings (Elbows, Tees, bends, Mitres, Reducers, flanges, Gaskets, Bolts, Nuts, CAPS, Blind flanges and end closures). The measurements will be based on the approved drawing I as built drawing and paid per unit running metre. Length of other fittings (valves and strainers), which are paid under appropriate item, shall not be re-measured under linear measurement. The bill of quantities specified does not include any wastages during fabrication and erection. These shall be included by the tenderer in the unit rate. Also the unit rate quoted shall include piping insulation for chilled Refrigerant piping and other pipes, no separate payment will be made for piping insulation.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

5. CEILING SUSPENDED UNIT

APPLICABLE TO BOQ ITEM –

The Ceiling Suspended unit shall be of modular type with pentapostframe(or equivalent to Eurovent standard) and sandwich panels. The panels and the post should be fabricated from heavy gauge galvanized steel sheet. Panels and frame shall be secured using internally bolted fixings so that welding is avoided and the integrity of the finish is maintained. The construction shall permit removal of panels for maximum access to fans, coils and filters. The panels and frame shall be factory painted with durable oven cured polyester based powder paint or powder coated.

5.1. CASING

The casing of the AHU should be of doubled skin construction. The main framework shall be of extruded aluminum hollow structural sections. Double skin panels shall be 40 mm thick fabricated out of minimum 0.8mm thick sheet with plain Pre-plasticized sheet as the outer skin and 0.8 mm perforated sheet for sound absorption or plain sheet as the inner skin. The material of insulation shall be pressure injected CFC-HFC free polyurethane foam or PIR insulation (Density 46 +2 kg/m³ with K factor not exceeding 0.02 W/m²

The base shall have clearance from the floor to ensure air circulation and avoid entrapment of moisture below the unit. The unit shall have a sloped stainless steel drain pan with a bottom/side connection to eliminate stagnation of condensate water. Drain pan shall have minimum 1mm thick sheet with 19mm thick closed cell nitrile rubber insulation. There shall be no sharp edges or corners or fasteners projecting out on the unit which might cause injury. Provide rubber caps for screws protruding inside the units. Sealing shall be by means of a non-hygroscopic gasket compressed between the frame and the panels. Access panels with hinged doors shall be provided to maintain and service the fan and filters.

All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury. The entire housing shall be mounted on galvanized steel channel frame work made out of G.I sheet of thickness not less than 2mm.

The air handling unit shall be provided with a limit switch on the door and the same shall be field wired to switch off the blower when the door is opened. The unit shall be provided with marine lights inside. The lights shall come on when the door is opened or by means of an external switch and wiring shall be done in the field accordingly. The air handling units shall be provided with aluminum outlet damper with PVC gears suitable for connecting to an actuator. The damper shall also be suitable for manual operation. The units shall be provided with one set of commissioning filters of throw away type apart from the regular set of filters. Permanent filters shall be installed once cleared by the Consultants/PMCs.

5.2. COOLING COIL SECTION

The Coils shall be of fin and tube type having copper tubes and aluminum fins. Coils should be AHRI Certified. Coil selection for each Coil to be submitted for approval before manufacturing. The tubes shall have a minimum diameter of 12.7 mm. The number of fins shall be 5 per cm. The tubes shall be mechanically expanded by means of a mandrel for optimum tube to fin bonding. The fins shall be plate or

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

spiral and tubes shall be staggered. Coils shall be provided with copper header and MS adaptor. Water pressure drop in coil shall not exceed 2 mt. of WC. Performance of Coil in accordance as per EN 1216 standard with a maximum tolerance of 5%. The air face velocity across the coil shall not exceed 300fpm. The coils shall have capped vent and drain connections provided on the headers. Cooling coils of water duty shall be tested for 7 KSC working pressure. The filter section shall be provided with the same casing construction as that of the unit. The coil shall be 4/6 rows deep for normal re-circulated air application, access door and independent drain pan. U bends shall be of copper, jointed to the tubes by brazing, soft soldering shall not be used. Each section of the coil shall be fitted with flow and return headers to feed all the passes of coil property.

5.3. FILTERS

The Pre filters shall be of panel type with synthetic non-woven washable type media with GI framework. . The filter shall have an arrestance of 90% down to 20 microns. The filters shall be easily removed for cleaning. Proper gaskets are to be provided to prevent air leakage through the filter section. Filters shall be provided as per the LEED requirement.

5.4. FAN

Fans shall be of centrifugal forward/backward curved type. The fan shall be plug-type direct-driven backward curved fan with, and base frame and vibration isolators. The casing shall be of minimum 1.2 mm thick sheet steel phosphate and then powder coated. The fan scroll shall be attached to the side plates by means of continuous lock seam or welded seam construction.

The inside surface finish of the fan casing shall be compatible with clean room practices. Directions of rotation shall be marked on the housing. Fan wheels shall be statically and dynamically balanced. The fan shall be selected with optimum outlet velocity and better efficiency resulting in lower noise levels. The fan shaft shall be constructed out of C-45 steel, turned, ground and polished. Fan shaft shall be ball bearing type directly mounted on the fan housing. Bearings should be of heavy-duty double row, self-aligning ball/roller bearings with plumber block. Fan motor shall be of sufficient capacity to overcome the BHP, the frictional and drive losses. Test certificates shall be provided. If required, Consultants/ Owners may visualize the factory testing. The noise level shall not exceed 50 to 55 dBA at 1 m from the unit. The motor shall be of TEFC squirrel cage type having class F insulation and IP 55 protection. The motor shall be of energy efficient type with high and flat efficiency curve for 50 to 100% load. The motor shall be suitable for operation using a variable frequency drive. Provide external terminal box for cable termination as a part of the fan motor. For all AHU's, the motor shall be of Plug-type. IP 55 protection to be provided and class 'F' insulation to be used. All rotors to be coated in black.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

6. EXHAUST FANS & FRESH AIR FAN

APPLICABLE TO BOQ ITEM –

All units to follow all the standards as per EUROVENT mentioned under AHU section.

6.1. CASING

The casing of the AHU should be of doubled skin construction. The main framework shall be of extruded aluminum hollow structural sections. Double skin panels shall be 25 mm thick fabricated out of minimum 0.8mm thick sheet with plain pre-plasticized sheet as the outer skin and 0.8 mm perforated sheet for sound absorption or plain sheet as the inner skin. The material of insulation shall be pressure injected CFC-HFC free polyurethane foam or PIR insulation (Density 46 +2 kg/m³ with K factor not exceeding 0.02 W/m²). There shall be no sharp edges or corners or fasteners projecting out on the unit which might cause injury. Provide rubber caps for screws protruding inside the units. Sealing shall be by means of a non-hygroscopic gasket compressed between the frame and the panels. Access panels with hinged doors shall be provided to maintain and service the fan and filters.

All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury. The entire housing shall be mounted on galvanized steel channel frame work made out of G.I sheet of thickness not less than 2mm. The air handling unit shall be provided with a limit switch on the door and the same shall be field wired to switch off the blower when the door is opened. The unit shall be provided with marine lights inside. The lights shall come on when the door is opened or by means of an external switch and wiring shall be done in the field accordingly. The air handling units shall be provided with aluminum outlet damper with PVC gears suitable for connecting to an actuator. The damper shall also be suitable for manual operation. The units shall be provided with one set of commissioning filters of throw away type apart from the regular set of filters. Permanent filters shall be installed once cleared by the Consultants/PMCs.

6.2. FILTER SECTION

The Pre filters shall be of panel type with synthetic non-woven washable type media with GI framework. The filter shall have an arrestance of 90% down to 10 microns. The filter dimensions to be in according to EN 15805. The filters shall be easily removed for cleaning. Proper gaskets are to be provided to prevent air leakage through the filter section. Filters shall be provided as per the LEED requirement.

6.3. FAN SECTION

The fan shall be plug-type direct-driven backward curved fan with, and base frame and vibration isolators. The fan chambers to be insulated with 13mm nitrile rubber open cell insulation. The fan scroll shall be attached to the side plates by means of continuous lock seam or welded seam construction. Direction of rotation shall be marked on the housing. Fan wheels shall be statically and dynamically balanced. The fan shall be selected with optimum outlet velocity and better efficiency resulting in lower noise levels. The

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

fan shaft shall be constructed out of C-45 steel, turned, ground and polished. Fan shaft shall be ball bearing type directly mounted on the fan housing. Bearings should be of heavy duty double row, self-aligning ball/roller bearings with plummer block. Fan motor shall be of sufficient capacity to overcome the BHP,

the frictional and drive losses. Test certificates shall be provided. If required, Consultants/ Owners may visualize the factory testing. The noise level shall not exceed 65 dBA at 1 m from the unit. The motor shall be of TEFC squirrel cage type having class F insulation and IP 55 protection. The motor shall be of energy efficient type with high and flat efficiency curve for 50 to 100% load. Wherever specified provide twin motor with frame work so that incase of the failure of one motor the other can be put into operation. The motor shall be suitable for operation using a variable frequency drive. Provide external terminal box for cable termination as a part of the fan motor.

For all AHU's, motor shall be of Plug-type. IP 55 protection to be provided and class 'F' insulation to be used. All rotors to be coated in black.

6.4. CENTRIFUGAL FAN

Fans shall be of centrifugal forward/backward curved type and it shall be of either double inlet double width or single inlet single width construction and either class I or II as per the tender specifications. The fan shall be plug-type direct-driven backward curved fan with, and base frame and vibration isolators. The casing shall be of minimum 2 mm thick sheet steel phosphate and then powder coated. The fan scroll shall be attached to the side plates by means of continuous lock seam or welded seam construction. The inside surface finish of the fan casing shall be compatible with clean room practices. Direction of rotation shall be marked on the housing. Fan wheels shall be statically and dynamically balanced. The fan shall be selected with optimum outlet velocity and better efficiency resulting in lower noise levels. The fan shaft shall be constructed out of C-45 steel, turned, ground and polished. Fan shaft shall be ball bearing type directly mounted on the fan housing. Bearings should be of heavy duty double row, self aligning ball/roller bearings with plummer block. Fan motor shall be of sufficient capacity to overcome the BHP, the frictional and drive losses. Fans shall be belt driven. Belt tension adjustment in the form of slide rails for motor shall be provided. Base shall be provided for each fan and shall be mounted on cushy foots. Test certificates shall be provided. If required, Consultants/ Owners may visualize the factory testing. The noise level shall not exceed 65 dBA at 1 m from the unit.

The motor shall be of TEFC squirrel cage type having class F insulation and IP 55 protection. The motor shall be of energy efficient type with high and flat efficiency curve for 50 to 100% load. Wherever specified provide twin motor with frame work so that incase of the failure of one motor the other can be put into operation. The motor shall be suitable for operation using a variable frequency drive. Provide external terminal box for cable termination as a part of the fan motor.

For all Ventilation fan, motor shall be of constant flow. IP 54 protection to be provided and class 'F' insulation to be used. All rotors to be coated in black.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Wherever specified provide cabinet type air handling units without cooling coils similar to the air handling units for supply and exhaust applications. The specifications for air handling units shall be applicable.

6.5. CIRCULAR INLINE FAN

The fans shall be of inline type powered by centrifugal fans. The fan shall be housed inside a GI duct casing with inspection door. Single skin circular INLINE Type Exhaust fans/ cabinet type direct driven inline fan, suitable for Outdoor/Indoor installation. Hydrogen sensor (Is required as per BoQ). The fan shall be suitable for mounting with the ducts. The fan shall be complete with a single or three phase motor suitable. The fan shall have the minimum static pressure as required. Provide speed regulators for fans with direct drive. The noise level of the unit shall not exceed 55 dBA at 1m from the unit

Fan shall be single skin with backward curved blades & external rotor / TEFC motor suitable for Normal Exhaust/Fresh Air Application. These fans shall be complete with casing, motor & impeller.

- **Casing** Fans casing should have an outer casing of galvanized sheet steel. The sheet steel must have a layer of 20 µm of zinc for protection against corrosion.
- **Impeller** should be backward curved with aluminum/Steel blades. These blades should be mounted on a galvanized steel plate. The impellers should be press fitted directly onto the rotor of the external rotor motor. In case of TEFC motor impeller should be placed on extended carbon steel shaft of the motor and impeller should be balanced dynamically.
- **MOTOR** - Fan motor should be external rotor type motor with built in thermal contacts for protecting against overheating. Compact in size and its construction should allow motor to be cooled by transported air. Three phase motors should be D/Y. Thermal contacts for overload protection should be provided and need to be connected to an external motor protection device for models with external rotor motors
- The motor bearings should be completely maintenance free and can be used at any installation position at indicated maximum temperature of transported air. Winding insulating shall be class F with degree of protection IP 55. Motor speed shall not exceed 1450 rpm.
- **Drive**- Fan should be direct drive to have reduced losses in transmission and higher efficiency. Fan should have an circular opening for inlet with square outlet for exhaust. Fan should be installed with weather protection cover when installed outdoor.
- Rectangular Cabinet Fan should be licensed to bear the AMCA Seal. The ratings should be based on tests and procedures performed in accordance with AMCA Publication 211 and AMCA Publication 311 and comply with the requirements of the AMCA Certified Ratings Program.

6.6. PROPELLER FAN

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Propeller fans shall be direct-driven, three or four blade type, mounted on a steel mounting plate with orifice ring. Propeller fans shall have MS powder coated or epoxy coated diaphragm. The impellers shall be die cast aluminum or MS powder coated epoxy coated with adequate gauge sheet. The fan shall be statically and dynamically balanced. The fan motor shall be suitable for outdoor installation and shall have minimum IP-55 protection. The fan shall be suitable for mounting vertically and should withstand higher temperatures. The fan shall be provided with bird screen, wire guard at the inlet and aluminum light gravity shutters built into the steel frame as a part of the fan. The fan shall be suitable for single, or three phase operation as specified in the tender conditions. Provide speed regulators as specified. The noise level of the fan shall not exceed 65 dBA at 1m from the fan.

6.7. KITCHEN EXHAUST FAN

APPLICABLE TO BOQ ITEM –

The Fan type shall be DIDW for Kitchen ventilation & Sewage Treatment Process Exhaust applications. Centrifugal fans shall be of double-width, double-inlet construction, with bearing on both sides, complete with access door, squirrel-cage induction motor, direct driven and mounting with weatherproof cowl. Housing shall be of heavy gauge sheet steel in 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 shall be provided throughout split joints to make it airtight. 1.2 mm galvanized wire mesh inlet guard of 5 cms sleeves shall be provided on both inlets. Housing shall be provided with access doors with quick locking tension handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing. Fan wheel shall be of GSS and backward curved non-overloading type unless otherwise specified. Fan wheel and housing shall be statically and dynamically balanced. Fan outlet velocity shall not exceed 610 meters per minute.

The entire assembly shall be weatherproof and raised from the roof terrace sufficiently to prevent down flow of rainwater accumulated on the terrace. Galvanized steel mesh bird screen shall be provided on all discharge cowls around the outlet areas.

DRY SCRUBBER

Dry scrubber for kitchen exhaust consisting of Electrostatic Precipitator, backward curve SISW centrifugal fan with elongated shaft having bearing & drive package out of exhaust air stream, TEFC induction motor, common channel base frame for Fan and motor, vibration isolation arrangement by means of spring type vibration isolators or turret mounts, fire retardant flexible canvass connections made out of canvass sleeve and the scope includes unit mounted starter panel in enclosure. The Electrostatic section shall be 90-95% in single pass as per DOP test method. Electrostatic Precipitator should be able to charge particles from 0.01 micron to 10 micron through solid state power supply. The collector cell shall be of permanent type and slide out facility for easy removal for cleaning. Operating voltage shall be 220+6 % volts, 50 Hz/1Ph, power consumption shall not exceed 50 watts per unit. System should be fitted with interlock switch for safety. Velocity across the air cleaner shall not be more than 500 FPM. Scrubber shall be provided with

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

pre-filters as required, pressure drop across ESP with pre filter should not be more than 12mm of Water gauge, . ESPs shall be provided with UV & Ozone Odours removers. ESP Modules shall have necessary provision in terms of flanges to facilitate Ducts/Plenum connections.

MISCELLANEOUS

Tenderer shall produce test certificates for the fans. The consultant/Owners may depute their representatives to visualize the tests. In case the air handling units are to be knocked down for easy shifting into the air handling unit rooms, the reassembling of the units shall be done by the authorized representative from the Manufacturers using proper tools and tackles. The unit shall be provided with factory made filter plenum, supply plenum. The noise level of unit shall not exceed 65 dBA at 1m from the filter side. After assembly the entire air handling unit shall be smoke tested for leaks. Conduct leakage tests as per SMACNA. The necessary external terminal box for cable termination shall be a part of the motor.

7. PIPE AND VALVE WORKS

APPLICABLE TO BOQ ITEM –

7.1. PIPES, JOINTS, VALVES & INSULATION

All chilled water, condenser water piping up to 150mm dia should be of medium class black steel conforming to IS: 1239. Welded black steel pipe class 2, conforming to ISO: 3589, for sizes greater than 150mm. These pipes should be factory rolled & fabricated from min. 4.65mm thick MS sheet for pipes up to 100mm Dia, 6mm thick MS sheet for pipes up to 400mm Dia and min. 7 mm thick MS sheet for pipes 401mm Dia& above. All pipe joints should be welded while screwed joints should be used for smaller sizes. Pipe flanges to be conforming to IS: 1536 whereas the threads should conform to IS: 554. The ends of pipe lengths to be welded should be cut square by a machine saw and the edges leveled to form a “V” groove before welding. Under no circumstances, the edges to be formed by gas cutting or welding. The pipe weld should be subjected to Radiographic/Die penetration test for minimum 10% of the welded joints and respective test certification to be provided to show case welding efficiency. Weld on flanges to be as per IS: 6392 and may be steel welding neck type or slip on type welded to the pipes. Flanges may be tack welded in position but all other welding to be done with the joint dismantled. Gaskets of 3 mm thick 3 ply rubber should be used with flanged joints. The screwed flanges should also conform to IS: 6392 and should be screwed to the pipes. The piping shall be complete with two coats of Enamel paint (color as per standards) and water flow direction for all pipes.

The supporting activity for all pipes to be duly approved by the respective support suppliers as mentioned in the approved makes of the tender. Separate set of drawings to be released clearly stating the supporting elements for all the pipes. All the supporting elements to be duly checked with structural team and architects before starting of the works.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

7.2. CPVC PIPE

APPLICABLE TO BOQ ITEM –

Chlorinated Polyvinyl Chloride (CPVC)/ PEX pipes, for Drain having thermal stability for cold water supply including all CPVC plain & brass threaded fittings . This includes jointing of pipes & fittings with one step CPVC solvent cement testing of joints complete as per OEM.

7.3. PIPE SUPPORTS

GENERAL SPECS RELATED TO ALL ITEMS OF MS PIPE

Piping to be properly supported on or suspended from stands, clamps, roller hangers, etc., as required. The contractor should adequately design all brackets, saddles, clamps and hangers and to be responsible for their structural integrity. Wherever pipes buried underground, the top of pipes to be buried with not less than 1m from the ground level. (Wherever this is not possible to achieve, the structural engineer in charge should enforce the top slab to ensure there is not damage to be pipes buried). The pipes shall be surrounded by all sides by sand cushion of not less than 150mm. After the pipes has been laid and top sand cushion has been provided, the pipes can be filled with excavated soil.

Each support should be isolated from the support by means of anti-vibration springs or durable liner of neoprene rubber. Pipe supports should be of steel and should be painted with rust preventive paint and finish coated with synthetic enamel paint of approved color. Only factory made supports with Galvanized fully threaded rods with bands are acceptable. The chilled water pipes should be isolated from the bands by a rubber sheet. These rubber sheet bands should not be removed from supports. Pipe supports on the terrace or exposed to weather should be hot dip galvanized.

The spacing of pipe supports should not be more than that as specified below:

NOMINAL PIPE SIZE IN MM	SPACING IN M
Up to 25 mm	2.5 m
32 to 150 mm	2.0 m
Above 150 mm	1.2 m

The GI support rods should be 8 mm thick for pipes upto 50 mm dia, 10 mm for pipes from 65 mm to 125 mm dia and 12 mm for pipes 150 mm dia and above. (To be confirmed with the structural team / architectural team)

Extra supports should be provided at bends and heavy fittings like valves/strainers to avoid undue stresses on the pipes. Suitably cut wooden second quality seasoned teak wood blocks should used for resting the pipe on the supports wherever required. Vertical risers should be parallel to walls and column lines .Risers passing from floor to floor should be supported at each floor by clamps or collars attached to pipe with a 12 mm thick rubber pad. Risers should also have a suitable elbow or concrete pipe support at the lowest point.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Pipe sleeves of 50 mm larger diameter than the pipe should be provided wherever pipes pass through the walls and the annular space filled with felt and finished with retaining rings. Insulated piping should be supported in such a manner as not to put undue pressure on the insulation. 2mm thick sheet should be provided between the insulation and clamps, saddle extending at least 10 mm on both sides of the clamps, saddles. All welded bends should be of 5 piece construction for pipe sizes 200 mm dia and for larger pipes at least 7 piece construction should be provided.

Drains should be provided at all low points in the piping system and should be of the following sizes:

MAIN LINE SIZE IN MM	DRAIN SIZE IN MM
Up to 300	25
Over 300	32

Drain to be provided with gate valves of equal size but with rising spindle. Alternatively, ball valves should be provided. Drain should be piped through G.I. medium class pipe to the nearest drain or floor waste. Piping should be pitched towards the drain points.

The joints should be proper so that no water leaks over the false ceiling. The pipes should be tested for leaks to a minimum pressure of 1 KSC before the false ceiling sheets are fixed.

8. DUCTS AND AIR TERMINALS

8.1. DUCTS & SUPPORTS

APPLICABLE TO BOQ ITEM –

All ducts shall be fabricated from either galvanised sheet steel conforming to IS: 277/92 having lock forming grade or Aluminium conforming to IS: 737. The coating of zinc shall conform to Class VIII. Only new, clean and bright sheets without watermarks shall be used. The Consultants/Owners reserve the right to reject the sheets not meeting the requirements. Fabrication of ducts to be as per IS : 655.

The ducting shall be totally CNC machine made with tedious type flanges or shall be fabricated using lock forming machines with angle iron flanges as specified. The design of supports for all types of ducts to be duly approved by the support vendors as specified by the tender.

8.2. CNC MACHINE MADE DUCTS WITH DUCTMATE TYPE FLANGES

RECTANGULAR DUCTING

APPLICABLE TO BOQ ITEM –

The ducting should be fabricated from coils. The thickness of the sheet for rectangular ducts should be as follows:

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

The maximum length of each duct piece should not exceed 1200 mm. Cut sheets should not be used other than elbows or for ducts having a size bigger than factory available sheet size. All ducting should be with duct mate type flanges and no C & SS joints will be acceptable.

MAXIMUM SIZE OF THE DUCT IN MM	MINIMUM SHEET GSS	THICKNESS IN MM ALUMINIUM
750 mm and below	0.63	0.80
751 mm to 1500 mm	0.80	1.00
1501 mm to 2250 mm	1.00	1.50
2251 mm and above	1.25	1.80

The slip on flanges should be with roll formed GI sections. The corner pieces should be suitable for inserting into the hollow web of the slip on flange. The slip on flange should be fixed by clinching or by pop riveting so as to have a rigid joint. The spacing should not exceed 150mm. Self tapping screws are not acceptable. Recessed groove should be provided in the slip on flanges and corner plates for the proper seating of gaskets.

The corner piece should be secured by electro galvanized carriage bolts with flange nuts. The gaskets should of self adhesive, microcellular, cross linked polyethylene foam type. The gaskets should be non-toxic, permanently semi-soft. Wherever specified provide PVC or Neoprene gaskets.) The ducts should be of medium pressure type having a pressure of 2000 Pascal's (Class II ducts) and the leakage should be as per SMACNA/DW 143 standards)The ducts should be provided with cross breaking having a span not exceeding 400 mm. The slip on flange should have thickness of 0.6 mm or ducts up to a maximum size of 500 mm; 0.8 mm for ducts having a size between 501 mm and 750 mm; 1.0 mm for ducts having a size of 751 mm to 900 mm; 1.25 mm for ducts having a size of 901 mm to 1200 mm and 1.5 mm for ducts having sizes higher than 1201 mm. The width of the flange should be 29 mm for ducts having a maximum size of 750 mm and 39 mm for higher sizes.

The duct section should reach right up to the end of the slip on flange. After installation of the slip on flange and corner plates, sealant should be applied only at the interface of the duct corner edge. Care should be taken to ensure that corners complete clear the duct edges and the corner piece should not sit on the duct corner edge. The gaskets should have width of 10 mm width and 4.5 mm thick for ducts having a pressure class up to 500 Pascal. For a pressure class above 501 Pascal, gaskets having a width of 15 mm and a thickness of 6 mm should be used. Care should be taken to ensure that gasket is properly seated in the groove of the slip on flange and corner plates in such a way that the gasket commences midway between the corners. The gasket should be applied in one piece and joined at the starting point with a butt joint. The gasket has to cut over the corners in an arc, protruding slightly into the air stream at the corners. The carriage bolt should be tightened using a ratchet or a spanner. Longer duct lengths should be aligned by passing a wire through the small round holes on the corner plates. Cleats should be inserted over the slip on flanges on all the sides using a special crimping tool.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

The spacing between the cleats should not exceed 150 mm. The ducts should be bolted directly on the top corner pieces with threaded rods anchored to the ceiling using a bracket having a slot for minor lateral adjustments. Wherever specified provide slotted channel/angle iron supports.

The support rod should be galvanized and fully threaded having a minimum diameter of 10 mm for duct size up to 750 mm and 12 mm for sizes above 751 mm. The anchor fasteners should also be the same size of the rods. Wherever support rods require joints the smallest rod length should not be less than 300 mm.

The galvanized steel slotted rail should have a thickness of 1.6 mm for ducts of size up to 750 mm and 2.4 mm for sizes above 751 mm but below 1500 mm. For sizes above 1501 mm use 40 x 40 x 5mm angles should be used. The spacing between supports should not exceed 2000mm for ducts having a maximum size of 1500 mm and 1200mm for higher sizes. Provide additional supports for bends, elbow, and collars as required.

All civil work including drilling, chipping, grip bolting and other related works should be within the scope of the air-conditioning contractor. Before drilling supports, alignment lines are to be marked on the ceiling to ensure that all the supports are in one line preferably using metal detectors trace the reinforcement bars on the slab. Care should be taken not to drill on the tendons in the case of post tensioned structures.

The ducts should be erected to the required levels after ascertaining the finished floor level markings using water tubes.

No ducts should be raised or lowered in levels as a whole system. The ducts are to be dismantled incase the levels are to be changed. In such a case the gaskets are to be replaced. Supports to be installed prior to the installation of the ducts.

No temporary supports or ducts supported to other services are acceptable. The entire duct including the insulation above the false ceiling should be painted with Matt finish black paint as a part of the duct works. The fabrication of the ducting including details of transverse joint connections, bracing, seams etc., for longitudinal joints etc., will be generally as per IS: 655.

The ducts should be rigid and should have very minimum leakage. Use silicone sealant at suspected leak points. The ducts should be of medium pressure type having a pressure of 2000 Pascal's (Class II ducts) and the leakage should be as per SMACNA/DW 143 standards). Only angle iron flanges should be used for all transverse joints and GS sheet flanges are not acceptable. Following should be the type of transverse joint and bracing for rectangular ducts.

GS sheet flanges are not acceptable. Stiffening angles should be fixed to the sides of the duct by riveting. Flanges should be welded at corners first and then riveted to duct.

All ducts should be provided with cross breaking on the sheets for stiffening irrespective of their sizes. All angles, rods and other MS members, materials, components etc., used for supports should be provided with a coat of zinc chromate primer and black paint during supply followed by a final coat of black paint after erection along with the ducting. Silicone sealant should be applied at angle iron flange/sheet corners or at places where there is a leakage.

No metal putty/paste should be used. Provide slotted channel/angle iron supports with threaded rods. The support rod should be galvanized and fully threaded having a minimum diameter of 10 mm for duct size up

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

to 750 mm and 12 mm for sizes above 751 mm. The anchor fasteners should also be the same size of the rods. Wherever support rods require joints the smallest rod length should not be less than 300 mm. The galvanized steel slotted rail should have a thickness of 1.6 mm for ducts of size up to 750 mm and 2.4 mm for sizes above 751 mm but below 1500 mm.

For sizes above 1501 mm use 40 x 40 x 5mm angles should be used. The spacing between supports should not exceed 2000mm for ducts having a maximum size of 1500 mm and 1200mm for higher sizes. Provide additional supports for bends, elbow, and collars as required. All civil work including drilling, chipping, grip bolting and other related works should be within the scope of the air-conditioning contractor. Before drilling supports, alignment lines are to be marked on the ceiling to ensure that all the supports are in one line preferably using metal detectors trace the reinforcement bars on the slab. Care should be taken not to drill on the tendons in the case of post tensioned structures. Elbows are to be provided with vanes. 3mm thick rubber gaskets are to be used.

The gaskets should be butt joined and should not sit over the other or there should be a gap between two gaskets. The ducts should be erected to the required levels after ascertaining the finished floor level markings using water tubes.

No ducts should be raised or lowered in levels as a whole system. The ducts are to be dismantled incase the levels are to be changed. In such a case the gaskets are to be replaced. Supports to be installed prior to the installation of the ducts. No temporary supports or a duct supported to other services is acceptable. The entire duct including the insulation above the false ceiling should be painted with Matt finish black paint as a part of the duct works. Exposed ducts should be painted with two coats of approved shade paint with zinc chromate primer. Quality check forms are to be prepared during various stages of installation works. Ducts without proper quality check forms will be rejected. All ducts are to be smoke tested after assembly in sections. Pressure testing should be done for select duct lengths as required by Consultants/owners. Insulation or painting of ducts should be done only after such tests and after rectification of leaks. Test reports should be submitted for such tests. Consultants/owners reserve the right to witness such tests.

8.3. AIR PLENUMS

APPLICABLE TO BOQ ITEM –

Air plenums should be modular in construction and factory fabricated with powder coated aluminum frame work and double skin panels. The insulation for the plenum shall be fabricated in two layers(Accoustic lining on the inside & thermal insulation on the outside). Inner acoustic insulation to be 19 mm thick open cell Nitrile Rubber type insulation with Density of the insulation to be not less than 32 kg/cum. Outer layer thermal insulation to be 25 mm thick closed cell Polyurethane foam type with Density of the insulation to be not less than 46 kg/cum. The panels should be powder coated and finished to the shade as that of the air handling unit. The panels should be fabricated out of 1 mm thick outer sheet duly powder coated and the inner sheet should be perforated having a thickness of 1 mm thick having minimum 30% perforations

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

should be used to perform the acoustic functions. Wherever specified, provide plain sheet having a thickness of 1 mm on the inside. For filter plenums provide plain sheet on the inside.

The plenum should be provided with factory cutouts for connection to the ducts and to the air handling unit. No site cutting is allowed. Necessary access door should be provided. The plenum should be hung from the ceiling using factory made supports using threaded rods having a thickness of 15 mm/12 mm rods depending on the size of the plenum. Inspection doors should be provided to permit access to heater boxes filters etc., on the plenums as required.

8.4. FLEXIBLE DUCTS

APPLICABLE TO BOQ ITEM –

Flexible ducts should be used for connecting the supply diffuser and exhaust diffuser plenum to the ducting. A double lamination of tough polyester should encapsulate a steel helix to form an air tight inner core. The double layer core should be wrapped in a thick blanket of fiberglass insulation and sheathed in a rugged and durable tri-directionally reinforced metalized polyester jacket. The insulation should have a thickness of 25 mm as specified. The ducts should be complete with accessories such as saddle straps for supports and worm drive clips for termination to the rigid metallic duct collars.

Longer flexible lengths exceeding 800 mm connecting the plenums and ducts are not acceptable. Single skin aluminum flexible ducts should be made of a triple lamination of aluminum foil, polyester and metalized polyester film permanently bonded to a coated spring steel wire helix. The PVC flexible ducts should be of fire retardant type. PVC flexible ducts without insulation should be used for connecting the toilet exhaust plenums to the ducts or connecting the exhaust ducts in the case of laboratories. The ducts should have pressure rating of 1500 Pascal's.

8.5. VOLUME CONTROL DAMPERS

APPLICABLE TO BOQ ITEM –

The AI volume control dampers should be of opposed blade type for throttling and parallel acting blades for isolation. The volume control damper should be fabricated out of extruded aluminum frame having a size of 110 mm x 40 mm x 1.5 mm thick sections.

The blades should be of aluminum aero foil double skin type having a size of 100 x 15 x 1.5 mm thick section with ribs on both sides to hold EPDM gaskets. The blades should be held together by aluminum square sections pivoted to the outer frame by means of PVC bushes. The linkage will be by means of nylon/PVC gears.

The outer frame should be provided with a stainless steel sheet all round to prevent air leakage. A GI quadrant handle should be fixed on one side with a marking of the open/ part, open and close positions with a locking screw.

The damper should also be suitable for connecting to a motorized actuator. MS/CRCA dampers are not acceptable. The dampers for motorized operation should require lesser torque. A limit switch is possible to be fixed onto the damper to ascertain the open/close position of the damper.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Single blade round balancing damper should have a 1.5 mm thick GI frame with 1 mm thick blades formed out of Galvanized sheets for sizes up to 450 mm and 1.5 mm thick for sizes up to 600 mm and above.

The damper should be complete with square plated steel hub with lanced retainers to have minimal air leakage. The damper should be provided with nylon bearings and manual locking quadrant.

8.6. FIRE DAMPERS

APPLICABLE TO BOQ ITEM –

To be fabricated out of 1.6 mm thick formed sections with plated solid steel stubs with permanently sealed bronze bearings. The dampers should be suitable for 90 minutes fire rating and should comply with UL rating. Certified fire damper should be of motorized spring return type with complete with temperature sensor and control panel. Provision should be made for fixing a limit switch to monitor the position of the damper wherever specified. The fire damper should be able to receive an external signal from the fire detection system for closure apart from the temperature sensor. Fire & Smoke damper complete with outer shell with 1.6mm thick galvanized steel frame and the blade/Leaf with 1.6mm thick GSS, control panel, temperature Sensors, Duct type smoke detectors, transformer to convert 240 V AC to DC Voltage, motorized electric actuator, spring return type extended sleeve 400mm / 600mm with complete boxing .(Torque selection for all fire damper actuator shall be approved by consultants/ clients).

CURTAIN TYPE Fire damper UL 555 certified of 90 mins rating , constructed with outer shell with 1.6mm thick galvanized steel frame and the blade/Leaf with 1.6mm thick GSS. And with necessary flanges for connection with Fusible Link & spring mechanism, the damper shall be held open by a replaceable fusible link rated at 74degC as per specifications and drawings. 96 degC, 145 deg C, 183 deg C rated links available . Fire damper and sleeve assemblies expand during periods of intense heat. Therefore it is essential that openings in walls or floors be larger than the fire damper and sleeve assembly to allow for this expansion. Minimum clearances required between the outside of fire damper sleeve assemblies and wall/floor openings are Galvanized steel fire dampers and sleeves: 1/8 in. (3mm) per foot of damper width and 1/8 in. (3mm) per foot height with a minimum clearance of 1/4 in. (6mm).

The fire dampers should have 0 leakages. The motor should be off ON/OFF type 12V/24V supply with 400/600 mm sleeve of 18G & Smoke sensor. Size not to exceed 1500 x 1000. Duct connections to the air handling unit at expansion joints should be with Metal to Fabric to metal flexible duct connectors. All the fire dampers to be provided with extended sleeve made of GI sheet of length 400mm.

8.7. GENERAL DETAILS

APPLICABLE TO BOQ ITEM –

The fabric should be of fiberglass weave with silicon rubber coating or PVC The duct connection should be of fire retardant type and should be provided with a zip. Cross talk silencers should be fabricated out of 0.8 mm thick duct having an L profile with acoustic insulation.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

The cross talk silencer will be supported by threaded rods. The cross talk silencer will be measured as a part of ducting.

Location of air outlets should be as shown in the drawings and frames should be used for/ fixing the grilles. Necessary frames for fixing of air terminals should be co-ordinate with interior agencies. During erection, ducts should be covered with polythene sheet or waste sheets at open ends to prevent ingress of dust/debris inside. After installation of the entire ducts, the ducts should be tested for leaks. The entire distribution system should be then balanced using a velometer. Measured air quantities should be within 5% of the specified air quantities.

Dampers should be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any point of time. Smoke test for testing the leakage should also be performed for all ducts. Consultants from time to time during erection may call for leak tests. Contractors should maintain quality check forms as per the tender formats. Ducts should be identified by areas and duct numbers in the quality check forms. Ducts not finding place in the quality check form may be summarily rejected.

Rat proofing, consisting of 1.5 mm thick GSS mesh should be provided for all open ducts, dampers, fan outlets and return air slits as a part of ducting/dampers/louvers. Mosquito proof net fabricated out of stainless steel mesh construction should be provided at the outdoor air intake louvers/grilles wherever specified. Where sheet metal ducts or sleeves terminate in wood work/MS frame work, masonry wall, tight joints should be made by means of closely fitting heavy angle iron flanged collars. All ducts should be totally free from vibration under all conditions of operation.

For special applications mount the ducts on saddles coated with rubber. Ducts erected/kept in site for erection should be sealed at the open ends using polythene sheet after fabrication and erection.

All ducts should be cleaned thoroughly on the inside and outside before being erected/commissioned. All ducts should carry the duct reference nos. for inspection visible from the bottom of the duct.

ALL THE COLOR CODES FOR ALL AIR DISTRIBUTION PRODUCTS TO BE AS PER THE REQUIREMENTS OF THE ARCHITECT/ CONSULTANTS.

8.8. AIR TERMINALS

All air outlets and intakes and accessories should be constructed from extruded aluminum powder coated sections as indicated in the tender schedules. The air terminals should be finished with the approved shade powder coating.

Applicable to BOQ Item –

The supply and return air Plate type diffusers should be fabricated using extruded aluminum frame having a thickness of 1.2 mm with removable core. The core should be preferably with single pressed sheet held together with aluminum pipes and aluminium tubes to hold the removable core to the outer frame. Provide perforated diffuser plates. The perforated sheet should have a thickness of 1.2 mm with minimum 70% perforations. The diffuser should be provided with opposed blade type collar dampers. Te opposed collar blade damper should be fabricated out of all aluminium extrusions with powder coating.

Applicable to BOQ Item –

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

The damper should be suitable for adjustment through the perforated sheet in case of perforated dampers. All diffusers to be mounted on grid false ceiling should be with regular flanges. The continuous grilles should be with extruded aluminum profiles with 20 x 16 x 1.2 mm thick frame. The louvers should have a profile thickness of 5 mm at the front and 2 mm at the rear.

The louvers should be spaced having a centre to centre distance of 12 mm with black aluminum space bushes. The grilles should be having a cleat for fixing on to the false ceiling. No screws should be fixed on the frame. The louvers should be provided with required angle of deflection as specified in the tender schedules.

The grilles should be preferable a single piece for lengths upto 3500 mm with end flanges. Wherever cut sections are used end flanges, end flanges should be provided having a length not lesser than 600 mm. Provide curved profiled grilles by ascertaining the site measurements. For grilles on round/spiral ducts provide curved frames to have a flush seating on the ducts. Framed supply and exhaust grilles should be with extruded aluminum profiles having a size of 20 x 16 x 1.2 mm thick.

The louvers should have a profile thickness of 5 mm at the front and 2 mm at the rear having a spacing of 12 mm with black aluminum bushes. Provide collar dampers as specified. Provide non-vision type fresh air grilles of powder coated aluminum for drawing fresh air louvers wherever specified suitable for fixing on to the windows/ventilators.

The louvers should be with mosquito net. Linear slot diffusers should be fabricated out of 20 x 60 x 1.2 mm extruded aluminum frame with internal T frame with black powder coated diffuser blade which should slide into the frames and is adjustable to achieve the desired flow. These should be held together by means of 8mm dia aluminum pipes and 20 x 20 x 1.2 mm thick square tubes and should be riveted using aluminum rivets.

Applicable to BOQ Item –

Floor grilles should be fabricated out of adequate thickness aluminum extruded sections suitable for taking the load of the equipments and people. The grilles should be complete with damper for throttling. Jet diffusers should be fabricated of aluminum sheet having a thickness of 1.2 mm complete with aluminum spinnings supported on the flange assembly which can be fixed to the duct collar.

The nozzle should of rotatable type. The diffuser should be power coated. Diffuser spigots should be suitable for installing below the ducts with flexible duct connection. The spigot should be complete with diffuser and should have a height not exceeding 150 mm.

The spigot should be fabricated out of GSS/Aluminum having a thickness of 1 mm and 1.2 mm respectively. Contractor should submit samples of all the approved makes mentioned in the tender.

Cross talk duct to be fabricated out of GSS/Aluminum having a thickness of 1 mm. The height of the duct is subjected to variation as per the site false ceiling requirements. The duct size to be of very low velocity of not more than 500FPM.

Applicable to BOQ Item –

Under flow air terminals to be linear type 1mm thick galvanized steel construction with pre painted flat black. The length of the grill to be not less than 1.2m and if necessary it should be provided upto 3m. The Linear

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

terminal shall be of variable air volume type. All the required cables and plugs to be included for each valve. The grill shall be extruded Al.

Under flow constant air flow volume diffuser to be fabricated out of 1.3mm galvanized steel catch pan assembly with pre painted flat black. Grill to be of Al. type. With sliding damper. All the under floor grills to be complying with NFPA 90a standards. (Load bearing to be not less than 550 Kgs). NC levels for all the diffusers to be not more than 17 for all flow conditions.

The power modules used for UFAD applications to be of 1mm thick galvanized steel box. The control transformer to be of 24V AC type. Necessary plugs and cables to be included per unit. The transformer should be consisting of built in circuit breaker. The thermostat used to be of Bacnet device so that it can be integrated to the VAV terminal. The thermostat should be of LCD display type with options of set point control.

The make approved by the Owners/Consultants/Architects should only be used. In case of a change in make during the execution as compared to the one proposed to the tender stage, no extra price should be paid for the makes approved during execution stage. A sample of each type of air outlet or intake that will be used during the job should be kept at the site. Provide diaphragm type (IRIS) dampers with flow measuring port for ventilated reagent shelves and other general purpose exhaust applications for laboratories.

8.9. TESTING OF EQUIPMENTS, PIPES AND VALVES

All piping should be tested to hydrostatic test pressure of at least 1 1/2 times the maximum operating pressure but not less than 7 KSC for a period of not less than 24 hours. All leaks and defects in joints and piping during the test should be rectified and got approved. Ambient temperature should also be recorded along with the pressure during the commencement and conclusion of the pressure tests. No pipe should be welded with water inside the pipes. Piping repaired subsequent to the above pressure should be retested in the same manner.

Systems may be tested in sections and such sections should be capped securely. Entire system should then be retested. Noiseless circulation of water in the circuit should be achieved. If improper circulation due to air lock is found, it is the responsibility of the air-conditioning contractor to carry out all the rectification including opening and refinishing of floor, wall etc., and Pressure gauges should be shut off during pressure testing.

The air-conditioning contractor should provide all materials, tools and instruments, services and labor required to perform the test and to remove the water resulting from cleaning and after testing. The consultants and the owners should be informed well in advance by the air-conditioning contractor of his intention to test a section or sections of piping and all such tests should be witnessed by the owners/consultants or their authorized representatives.

Test certificates duly signed by the contractor and the owners/consultants should be submitted by the contractor after completing the tests. No insulation should be applied to pipes unless the pressure testing is completed to the satisfaction of the owners/consultants. Insulation should be done as per the tender specifications.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

After completion of the installation, the pipe lines are to be flushed thoroughly to blow out all the dirt and muck. The pipe water flushing activity to be performed for minimum 3 times before the system can be operated. In between the pipe flushing activity there shall be chemical components used to remove all the unremoved welds and other impurities before the start of all the equipment's.

The flushing activity to be performed from the highest point and where possible the flow of the system to be followed. Verification of mesh or strainers is mandatory before the process of flushing. All the necessary motors, actuators, control valves are clearly isolated or removed (and safely located) during the flushing activity and any failure of actuators due to flushing activity shall be replaced by the same make & cost to be paid by the contractor.

Commissioning strainers should be used before all equipment's. The system then should be balanced to deliver the water quantities as specified. Balancing report after certification should be submitted with completion drawings and documents. Exposed Pipelines should be provided with one coat of primer and 2 coats of paint of color and quality as specified. Insulated piping and valves should also be provided with painting in a similar manner. Direction of flow should be marked on pipelines in bold markings. Provide expansion joints to prevent bending, bowing of pipes resulting in unusual stresses.

The expansion joint should be complete with anchor bases, inner liners, tie rods, outer jackets and flanges. The expansion joints should be of stainless steel. Provide flanged rubber bellows at pump, chiller inlets and outlets which are assumed to be part of the equipment's. Condenser water piping should be painted with two coats of enamel paint having apple green shade.

Provide automatic air vents at highest points. The body shall be of cast iron and the float and leverage shall be of stainless steel. The operating pressure shall be 150 psig. Air vents, purge and drain valves are considered to be a part of the piping and no extra cost will be paid for the same.

8.10. INSULATION

PIPES & VALVES INSULATION

APPLICABLE TO BOQ ITEM –

For Plant room piping & Valves, insulation thickness should be as mentioned in the BOQ. Chilled water piping should be insulated with rigid polyurethane foam of minimum density 32kg/m³, thermal conductivity of 0.023W/mk at 25°C., it should be covered with 120 gm/sq.m two layer vapor barrier and covered with 26 G Al. Cladding. The insulation to be CFC free and to have compliance with Class O fire standard. The adhesive used to be as per OEM.

For shaft risers and AHU room pipes located within the building, insulation shall Electron beam cross-linked polyolefin foam of minimum density 25kg/m³ and of thickness as mentioned in the BOQ. The thermal conductivity of the material to be not less than 0.032W/mk at 25°C. The insulation should be covered with single layer of 120 gm/ Sqm. vapor barrier and to be provided with 9micron Al. reinforced material. The

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

insulation to be CFC free and to have compliance with Class O fire standard. The adhesive used to be as per OEM.

For all chilled water valves coming inside AHU rooms, the insulation shall be Elastomeric Nitrile Rubber of minimum density 36kg/m³, thermal conductivity of 0.036W/mk at 25 ° C. The insulation should be finished with 26 G Al. cladding.

For buried pipes, the insulation shall be Closed cell Polyurethane foam insulation. The density of the insulation to be not more than 48kg/m³ & Thermal conductivity to be not more than 0.023 W/mK at 25°C. The insulation to be performed through spray type technology or to be injected into the annular space between a service pipe & insulation jacket.

Prior to application of insulation, all pipe work shall be cleaned on the surface with wire brush to remove dirt and dust. Apply a thick coat of bituminous primer uniformly over the surface. Bitumen used shall be R 85/25. High density insulation shall be inserted below the pipes between the RCC sleepers over a 1 mm thick GI sheet. Insulation to be covered with 5 mm HDPE Jacket for all buried pipes. Thermal insulation for all Elbows, bends, Tees etc shall be applied as per the following thickness taking care to see that circumferential joints are staggered longitudinally. Chicken wire mesh of 24G x 19mm hexagonal GI wire shall be wrapped around the insulation and two layers of smooth setting sand cement plaster each of 6mm thick shall be applied over the lath of wire mesh. The proportion of cement to sand shall not be less than 1:3. Curing to be done to the sand cement plastered surface. Cover the insulation with 6 mm thick Tar felt set in air blown grade bitumen. It shall be finally finished with 5mm HDPE jacket.

For exposed pipes & valves, Elastomeric insulation duly laminated with Al. foil of thickness not less than 300 micrometer (As per DN 53 370) & weight not less than 388 g/cum (As per EN 22 286). Insulation shall be having thermal conductivity of not less than 0.039 W/mK at 38°C, shall be complying with Class 'O' fire standards (As per BS 476 part 6/7) and finished with Al. cladding of 0.63mm thickness.

Prior to applying any insulation, the pipes shall be clearly wiped for any moisture content and a coat of zinc chromate primer shall be provided. After this, the insulation to be applied using the self-adhesive provided with the insulation supplier. The joints in between the insulation to be covered with 3mm fiber cloth tape so that there is no gaps in between the insulation joints.

8.11. DUCT INSULATION

APPLICABLE TO BOQ ITEM –

Supply air ducting should be insulated with 15mm thick Elastomeric Nitrile Rubber /NBR thermal conductivity not more than 0.036W/mk. with 7mili thick Fiber glass cloth plus two layers of shield coating. Ducts running in the return air path should be insulated with 15 mm thick insulation and insulation type and thickness to be similar to supply air ducting. Clean the surface of the duct with a wire brush to remove dirt and dust. Stick the insulation using water based adhesive as recommended by the OEM.

Exposed ducts to have Supply & Installation of Physically cross linked, closed cell Polyolefin foam with factory applied heat laminated reinforced aluminum foil of thickness not less than 300 micrometer(As per DN 53 370) & weight not less than 388 g/cum(As per EN 22 286). Insulation shall be having thermal

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

conductivity of not less than 0.033 W/m K at 38°C, shall be complying with Class 'O' fire standards (As per BS 476 part 6/7). Insulation shall be having thickness of 25mm for the exposed type ducts and also to have sufficient UV resistance since it is used for outdoor type applications.

Clean the duct surface and apply a thick coat of bituminous primer. When the insulation is till tacky, apply the blanket of insulation material, so that it sticks to the ducts completely. Seal all the joints using 75 mm wide self-adhesive aluminum tape as specified by OEM. To further ensure that the insulation is laid tightly on the duct, wrap nylon packing strap around the duct at a spacing of not less than 600 mm along the length of the duct. Paint the insulation with black paint having matt finish.

Ducts identified in the tender schedule for acoustic lining should be provided with 15 mm thick open cell nitrile rubber insulation material having acoustic properties inside the ducts. Wrap the insulation with RP tissue and secure the same to the ducting using GI bolts and nuts and plate and bitumen washers. Alternatively use pop up type saddled clamps. The clamps should be fixed to the ducts by adhesive.

of the wall should be done using 50 mm thick, density 32 Kg/cu.m resin bonded glass fiber or 48 Kg/cu.m rock wool insulation friction fixed in 610mmx610mm frame work made of 25x50x50x50x25mm made out of 0.6mm thick GI sheet 'U' shaped channel and finished with 0.8mm perforated aluminum sheet .

Clean the surface to remove all dirt and dust. Apply two coats of shalacote primer. Friction fit the fiber glass in the 0.61m x 0.61m. Cover the insulation with 26 G perforated aluminum sheets. The corners and junctions/terminations should be covered with aluminum angles/flats/sections. Alternatively prefabricated panels should be used and slide on to the frame. No wood should be used.

8.12. CONTROLS & INSTRUMENTATION

The scope of this section comprises supply, installation, testing and commissioning of controls and instruments conforming to these specifications and in accordance with the requirements of the tender schedules. This chapter also covers the requirements of equipment safety controls, refrigerant flow controls, system controls, and variable speed drive (VSD). For chilling units all the controls shall be microprocessor based.

8.13. EQUIPMENT SAFETY CONTROLS

COMPRESSOR

It should be provided with the following controls,

High discharge pressure (HP) safety (cut out) to stop the compressor automatically, in case discharge pressure exceeds a pre-set safe value. This safety shall operate when discharge head pressure exceeds the set point. Only manual resetting shall be provided for this safety.

Low suction pressure (LP) safety (cut-out) to stop the compressor automatically, in case suction pressure falls below a pre-set value.

Oil pressure (O.P) safety (cut-outs) to stop the compressor, in case lubricating oil pressure falls below a safe set value. High bearing oil temperature cut-out (for centrifugal compressor only). This shall be provided with a manual reset only. High lubricating oil temperature cut-out (for centrifugal compressor only). This

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

shall be provided with a manual reset only. Time delay mechanism on the starting gear to limit short cycling regardless of mal-functioning of controls.

The cut-outs mentioned above shall operate when the respective controlled variable crosses the set point to trip the compressor. Audio visual alarm shall be provided to indicate such operations. A manual reset shall be provided for them

8.14. CONDENSOR

The safety control for a condenser shall comprise a safety pressure relief valve on the shell. This shall operate to relieve the pressure at the set point without prior leakage. For small condensers, a fusible plug may be provided to melt at a predetermined temperature.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

MEASUREMENTS

The procedures to be followed for measurement of variable items shall be as follow:

DUCTING & DUCT INSULATION

1. Ducting shall be measured on the external surface. The rate per sq.mt of external surface shall include flanges, gaskets, bolts and nuts, duct supports, hangers, anchor fasteners, vanes, access doors and painting. Duct measurements shall be taken before the insulation is applied. Duct measurements shall be taken well before the installation of the false ceiling grids.
2. Duct insulation will be same as the area of the uninsulated ducts.
3. Grilles and dampers shall be measured on a cross sectional area basis excluding flanges.

PIPING & PIPE INSULATION

4. Pipes shall be measured on linear basis and shall include all fittings, flanges, unions, gaskets for joints, bolts and nuts, pipe supports, vibration isolators, flexible connections, excavation and refilling of earth, painting of pipes etc., Flexible bellows for equipment's will not be considered for measurements.
5. Insulation shall also be measured on a linear basis and shall include all fittings as mentioned above and shall be the same as the pipe measurements.
6. Valves and strainers shall be measured on a unit basis.

CABLING & CABLE TRAYS

7. Cabling shall be measured on a linear basis from gland to gland and shall include the excavation and refilling of the earth, sand cushioning etc.
8. The end terminations are measured on a unit basis.

Cable trays are measured on the basis of linear basis which includes supports, clamps, grouting etc.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

9. TESTING & BALANCING OF AIR IN HVAC SYSTEMS

9.1. BALANCING OF AIR

PART 1 – GENERAL BALANCING PROCEDURE

HVAC air and water systems call for a systematic approach. While there is no one specific balancing procedure, the following is a general procedure which can be applied to all systems.

Do the preliminary office work.

Gather plans and specifications.

Prepare report forms

Do the preliminary field inspection.

Inspect the job site.

Inspect the distribution system.

Inspect the equipment.

Make initial tests on all fans and pumps applicable to the system being balanced.

Balance and adjust the distribution system.

Adjust the fan or pump as needed.

Take final readings.

Complete reports.

PRELIMINARY FIELD INSPECTION.

After the reports are prepared, inspect the job site to see that the building is architecturally ready to be balanced. For instance, are all the walls, windows, doors, and ceilings installed? If the conditioned space isn't architecturally sealed, abnormal pressures and temperatures will adversely affect the system balance. Next, walk the air and water distribution systems to ensure that they are intact, and aren't missing components such as dampers, valves, pressure and temperature taps, coils, terminal boxes, diffusers, grilles, etc. Lastly, inspect the equipment. Check those motors, fans, pumps, chillers, compressors, boilers, drives, etc. are mechanically and electrically ready.

The following is a general list of items to be checked.

- Air Side
- Ductwork intact and properly sealed.
- Ductwork leak tested.
- Access doors installed and properly secured.
- Ductwork installed according to the drawings and specification.
- Ductwork free from debris.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

- Dampers, including fire and smoke dampers, are installed and accessible.
- Terminal boxes, reheat coils, electrical reheat, etc. installed, functional and accessible.
- All other air distribution devices such as diffusers, etc., installed, and functional.
- Return air has an unobstructed path from each conditioned space back to the unit.
- Filters clean and correctly installed.
- Filter frame properly installed and sealed.
- Coils cleaned and properly installed.
- Drive components installed.
- Sheaves properly aligned and tight on their shafts.
- Belts adjusted for the correct tension.
- Belt guard properly installed.
- Automatic control dampers installed and functional.
- Fan vortex dampers are functional.
- Fan housings installed and properly sealed according to the drawings and specifications.
- Flexible connections installed properly.
- Fan wheel aligned properly and adequate clearance in the housing.
- Fan bearings lubricated.

PART 2 – PRELIMINARY AIR BALANCING PROCEDURE

Before start of any balancing procedure for an area, the following items needs to be kept ready prior to start of work, Gathering of all the respective plans, specifications and data of all the equipment's that needs to be balanced. Prepare all report forms to record all the readings taken during the balancing of the air system. Lastly, prior to inspection, a checklist must be prepared and carried out to record pre-inspection of the area to be balanced.

Preliminary Field Inspection

- Walk the system,
- Verify that it is intact and sealed as applicable.
- It should be clean (no trash, loose insulation, or excessive quantities of dirt).
- Look for missing components such as end caps, dampers, turning vanes, terminal boxes, diffusers, grilles, etc.
- Ensure that the correct air distribution device is installed. It's not unusual for terminal boxes to be switched.
- Check that all fire and smoke dampers are installed.
- Confirm that return air openings are installed for ceiling return plenum systems.
- Note any major changes in actual installation as compared to design. Make corrections on the schematics. Also, on the schematic make corrections for location changes of dampers, diffusers,

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

and other accessories.

- Inspect the unit equipment.
- Motors wired.
- Fans and drives mechanically sound and free from debris.
- Filters and coils intact and clean

Startup Tests

Air Distribution:

Begin the testing of the system by setting the automatic temperature controls to full cooling. Check that the cooling coil is dehumidifying and is, therefore, in a “wet” condition. If the coil is “dry” the pressure drop across the coil will be lower than when the coil is wet and therefore, the volume readings will be higher. If the system is balanced in a dry condition, the total airflow will be low when the coil is dehumidifying. However, sometimes it may be necessary to balance with a dry coil. This is all right, as the system will be proportionally balanced; however, the fan speed may need to be increased when the system is rechecked with a wet coil.

Check that automatic temperature controls are properly sequencing and holding the volume dampers in place. If the dampers aren’t holding, either because of a malfunction or because the control system isn’t finished, disconnect the control linkage, and block the dampers in the full cooling position as follows:

Systems with face and bypass dampers—the face dampers are fully open, and the bypass dampers are fully closed.

The outside air damper is set approximately at minimum position.

The return air damper is fully open.

For manual dampers, straighteners and diverters check the following:

All smoke and fire dampers are fully open, as applicable.

All extractors, distribution grids and other accessories are set for maximum air flow.

All supply and return dampers including dampers at diffusers and registers are fully open.

All air pattern devices in diffusers and grilles are properly set.

All splitter devices are set in a non-diverting mode.

Fan Rotation:

Check the rotation of motors to ensure that fans are rotating in the correct direction. Certain centrifugal fans will produce measurable pressures and some fluid flow, sometimes as much as 50% of design, even when the rotation is incorrect. In axial fans, if the motor rotation is incorrect, the airflow will reverse direction. To check rotation, momentarily start and stop the fan motor to “bump” the fan just enough to determine the direction of rotation. There’s usually an arrow on the

fan housing showing proper rotation. However, if there’s no arrow, view double inlet centrifugal fans from the drive side and single inlet fans from the side opposite the inlet. This will let you determine proper rotation and whether the wheel is turning clockwise or counterclockwise. If the rotation is incorrect, it can

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

be changed in the field. To reverse the rotation on a three-phase motor, change any two of the three power leads at the motor control center or disconnect. In some cases, you may also be able to change rotation in single-phase motors by switching the internal motor leads within the terminal box. Wiring diagrams for single-phase motors are usually found on the motor or inside the motor terminal box.

Observe the fan rotating in the proper direction. If any excessive noises or vibrations are observed, stop the fan and investigate. Before continuing the testing phase, determine if the fan can be operated or if it needs repairing.

Voltage

Voltage measurements are made using a voltmeter which measures the difference in potential between phases, or between phase and neutral. The most accurate voltage will be read at the motor terminal box; however, it's usually much safer to take readings at the motor control center or at the disconnect box. The voltage difference between the two places is generally insignificant. The measured voltage should be plus or minus ten percent of the motor nameplate voltage. If it's not within this range, notify the electrical contractor or the utility company. On a three-phase motor, if the voltage isn't identical from phase-to-phase, and this is generally the case, there's a voltage unbalance. When there's a phase voltage unbalance there's also a current unbalance which can be as much as 10 times the percent of voltage unbalance. This means that the motor runs hotter than the design which, if the unbalance is large enough, can reduce the life of the motor. Therefore, the maximum allowable phase voltage unbalance for a three-phase motor is 2%. To check for voltage unbalance, use the equation:

% voltage unbalance = maximum deviation from average voltage times 100 divided by average voltage

Current

Current is measured using a clamp-on ammeter. The amperage measured on any phase shouldn't exceed the motor nameplate amperage. However, if the operating amperage reading is over the nameplate amperage, take one of the following steps to correct the problem.

The reading is over the nameplate amperage but within the service factor and voltage limits: Reduce the rpm of the fan or close the main discharge damper until the amperage reading is down to nameplate or below.

The reading is over the nameplate amperage and outside the service factor limit: Immediately turn the fan off and inform the person responsible for the fan. An exception is if the fan has been running and it's serving a critical area such as a cleanroom or surgical room, leave the fan operating and immediately notify the person responsible for that fan's operation.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Power Factor

Measuring power factor isn't presently a standard requirement in the testing and balancing industry; however. Power factor is read with a power factor meter.

Fan and Motor Speed

Two types of instruments, contact and non-contact tachometers, are used for measuring rotational speeds. Readings should be taken until you have two consecutive, repeatable values.

PART 3 – AIR BALANCING PROCEDURES

Balancing Principles

Balancing is measuring air volumes and adjusting volume control devices to get desired airflow. Fan speeds may also need adjusting. Unless otherwise specified it's generally considered there's an adequate balance

when the air quantities measured on the job are within plus or minus 10 percent of desired quantities. The first step in balancing the distribution system is to determine the total air volume. This is accomplished by Pitot tube traverse of main and branch ducts as applicable and the reading of all the supply air outlets.

Pitot Tube Traverse:

If the velocity of the air stream in a duct were uniform, only one reading at any point in the duct would be enough to determine volume of flow. Generally, the velocity, because of friction, is lowest near the sides of the duct, and greatest at or near the center. Therefore, a Pitot tube traverse of the duct is needed to determine the average velocity in the duct at the point of traverse. Having found the average velocity, the volume of air in the duct can then be mathematically calculated using the equation $Q = AV$. Where air quantity (Q) in cubic feet per minute is equal to the area (A) of the duct in square feet times the average velocity (V) in feet per minute.

$$d = \sqrt{4ab / \pi}$$

Where:

d = equivalent duct diameter in inches

a = length of one side of rectangular duct in inches

b = length of adjacent side of rectangular duct in inches

$$\pi = 3.14$$

Velocity Pressure Readings:

To take velocity pressure reading with the manometer, open both the high and low tubing connectors to atmosphere. Using two pieces of tubing connect one piece of tubing to the total pressure connection on the

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Pitot tube and the other piece of tubing to the static pressure connection. Then connect the total pressure tubing to the left side of the manometer and connect the static pressure tube to the right side of the manometer. Velocity pressure is the subtraction of static pressure from total pressure and because total pressure is always greater than, or equal to, static pressure, then velocity pressure will always be a positive value. This means that when measuring velocity pressure using the Pitot tube, the hook-up is always the same no matter if the reading is taken on the discharge of the fan or on the inlet. Check the tubing, especially at the connection ends, for leaks. Also, check that the impact and static holes aren't plugged (particularly when using in insulated ducts). Insert the Pitot tube into the duct facing into the air stream and record the velocity pressure (VP) readings. Continually check to see that (1) the manometer is level, (2) the meniscus is zeroed, and (3) that the Pitot tube is parallel to the air stream.

Calculating Air Volume:

A Pitot tube traverse is made to determine the average velocity of the airflow in the duct. Since the readings from the manometer are velocity pressure (VP) and not velocity (V), it's necessary to convert VP to V using

$$V = 4005 \sqrt{VP}$$

Equation 3-2

Where: V = velocity in feet per minute (fpm)

4005 = constant

\sqrt{VP} = square root of the velocity pressure in inches of water gage

To get average velocity convert each velocity pressure reading to velocity, total the velocities and divide by the number of readings. Air volume is calculated by using Equation 3.3:

$$Q = AV$$

Equation 3-3, Where: Q = quantity of air in cubic feet per minute (cfm)

A = cross sectional area of the duct in square feet (sf)

V = velocity in feet per minute (fpm)

PART 4 – AIR BALANCING PROCEDURES

This unit outlines the procedure for proportionally balancing low pressure constant volume systems and the low-pressure side of any system whether it be a constant or variable air volume system; low, medium, or high-pressure system; or single zone, multizone, or dual duct system.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

INSTRUMENTATION

Anemometers

In the field, the airflow through the outlets (or inlets) may be measured using a rotating vane anemometer for sidewalls (grilles and registers), or a deflecting vane anemometer for sidewalls and ceiling diffusers. Anemometers require a correction or flow factor for each outlet to convert velocity readings to cfm. In addition to the manufacturer's flow factor for the outlets/inlets, the anemometer may also have a calibration or correction factor.

Capture Hoods

A capture hood may also be used to measure sidewalls and ceiling diffusers. The capture hood is the easiest and most reliable instrument to take outlet/inlet readings because the airflows are read directly in cfm and flow factors aren't needed.

However, if a capture hood reading is in question, and a correction factor seems indicated, because of extraordinarily high or low velocities or an unusual use of the capture hood, take a traverse of the duct and determine a correction factor. In addition to a field-measured correction factor for air devices, check the capture hood for a manufacturer's calibration or correction factor.

Proportionally Balancing Low Pressure Systems

The principles of proportionally balancing require that all the dampers in the distribution system be fully open and that at least one outlet volume damper (the outlet with the lowest percent of design flow) will remain open. If the system has branch ducts, at least one branch volume damper (the branch with the lowest percent of design flow) will also remain fully open. Because the air outlets are on the low-pressure side of any system the following proportional balancing procedure can be used on constant or variable air volume systems: low, medium, or high-pressure systems; or single zone, multizone, or dual duct systems.

Procedure:

Determine which outlet has the lowest percent of design flow (%D). Typically, the outlet with the lowest %D will be on the branch farthest from the fan. This outlet will be called the "key" outlet.

Design flow is either the original design flow per the contract specifications or a new calculated design flow. Percent of design flow is equal to the measured flow divided by the design

$$\%D = \frac{M}{D}$$

flow:

If anemometers are being used the measured and design flows will be in feet per minute (fpm), whereas if capture hoods are used, the flows will be in cubic feet per minute (cfm). All the system balancing examples in this book will use cfm as the measured flow.

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
HVAC / 001	MATERIAL SPECIFICATION – HVAC WORKS	AD/0123

Starting with the key outlet, as needed, adjust each outlet on that branch duct in sequence, from the lowest percent of design flow to the highest percent of design flow,

The ratio of the percent of design flow between each outlet must be plus or minus 10%. Ratio of design flow is equal to outlet X %D divided by outlet Y %D. b.

To reduce airflow, volume dampers in the system should be adjusted in the branch ducts and at the takeoffs and not at the outlet since dampening at the outlets results in excessive noise and poor air distribution.

Go to the branch that has the outlet with the next lowest percent of design flow as determined from the initial readout. Typically, this “key” outlet will be on the second farthest branch. Balance all the outlets on this branch to the key outlet to within plus or minus 10% of design flow.

Continue until all the outlets on all the branches have been balanced to within plus or minus 10% of each other.

Starting with the branch with the lowest percent of design flow as the key branch proportionately balances all branch ducts from the lowest %D flow to the highest %D flow to within 10% of each other.

Continue until all branches have been balanced.

Adjust the fan speed if needed to bring the system to within 10% of design flow.

Reread all the outlets and make any final adjustments.

HVAC STANDARDS

- AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)
- INDIAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ISHRAE)
- ASHRAE 55 (2004; Interpretation 1: 2005; Errata 2006; Interpretation 2:2007; Errata 2007; Addenda's a & B 2008) Thermal Environmental Conditions for Human Occupancy
- ASHRAE 62.1 (2007; INT 2007; INT 2-15 2008; Errata 2008; Addenda a, b, e, f and h 2008) Ventilation for Acceptable Indoor Air SECTION 23 76 00.00 20 Page 4 Quality
- National Building Code -2016
- ECBC – 2017