COMMERCIAL AND ADDITIONAL CONDITIONS

1.0 General

1.1 This specification covers manufacture, testing as may be necessary before dispatch, delivery at site, all preparatory work, assembly and installation, final testing commissioning, i/c one year guarantee period for the following work:-

C/o IISER Mohali. SH: Providing Air-Conditioning at Stem cell, Virus lab, Tissue culture, FACS, confocal and Micro dissection lab.

1.2 The work shall be executed as per General specifications for HVAC works relevant IE rules, relevant IS and as per directions of Engineer-In-Charge. These additional specifications & conditions are to be read in conjunction with above and in case of variations; specifications given in the Additional specifications and conditions shall apply. However, nothing extra shall be paid on account of these as the same are to be read along with schedule of quantities for the work.

2.0 Commercial Conditions

2.1 Type of contract

The work to be awarded by this tender shall be treated as indivisible works contract.

3.0 SUBMISSION OF TENDER:-

3.1 The tender is in three parts:
a) Part-I – EMD.
b) Part II – Technical cum Commercial Bid
c) Part III – Price Bid

3.2 The tender shall be submitted duly completed in three separate sealed envelopes (i) Part-I EMD, Part-II Technical and Commercial Bid, and the other for Part-III Price Bid. All these bids shall be submitted together on or before the due date and time. The name of the work "EMD"/"Technical-cum-Commercial Bid only" / "Price Bid only" shall clearly be super scribed on the top of the respective sealed envelopes. All of these envelopes shall be put in the one big envelope with name of work details.

3.3. First Envelop- The name of work and with Part-'I' "Earnest Money Deposit" should be written on the top of the sealed cover. This shall be opened first. If EMD is found to be in order, other envelopes shall be considered for opening else the tender shall be rejected. Second Envelop – The name of work and the words "Part-II-Technical-cum-Commercial Bid" should be written on the top of the sealed cover. It shall be submitted complete with the following documents: -

i) Complete tender documents (Part-II) in original, as purchased from CPWD including the schedule of work (without indicating the prices) duly signed for acceptance of all terms and conditions.
ii) Deviation, if any from NIT specifications should be clearly brought out.
iii) Complete technical particulars of all equipments & materials as per proforma.
iv) Technical literature and catalogues of all equipments, performance curves of pumps etc.
v) Confirmation that existing space available is adequate for installation of equipments being offered by the tenderer.

3.4 Third Envelop – The name of work and the word Part-III – “Price Bid” should be written on the top of the sealed cover. The envelope should contain price bid offer only. The tenderers should fill up their rates in the price bid (Part-III of tender) in the format, issued by the department. The rates/ amount in this schedule should be filled up in figures as well as in words. Tenders in which the price bids are given in any other format, are liable to be rejected. The abstract of cost will also be required to be filled in. In the price bid, there shall be no condition whatsoever. Firms should clearly note that price bids with any condition including that of conditional rebates shall be rejected forthwith.

3.5. The tenderers are advised not to deviate from the technical specifications/ items, commercial terms & conditions of NIT like terms of payment, guarantee, arbitration clause, escalation.

3.6. The EMD envelop followed by technical cum commercial bid only, shall be opened first on the due date and time, as specified in form CPWD-6, in the presence of tenderers or their authorized representatives who wish to remain present.

3.7. Scrutiny/ evaluation of the Technical-cum-commercial bid shall be done by the department in consultation with any agency as deemed necessary. In case it is found that the technical-cum-commercial bid of a tenderer is not in line with NIT specifications, requirements and/ or contains many deviations, the department reserves the right to reject the technical bid of such firm(s) without making any reference to the tenderer(s).

3.8 Necessary clarifications required by the department shall have to be furnished by the tenderer within the time given by the department for the same. The tenderer will have to depute his representative to discuss with the officer(s) of the department as and when so desired. In case, in the opinion of the department a tenderer is taking undue long time in furnishing the desired clarifications, his bid will be rejected without making any reference.

3.9 After obtaining clarifications from all the tenderers, the department may modify the Technical & Commercial Conditions/ Specifications, if required, and will intimate the tenderers whose Technical-cum-Commercial bids are acceptable. The date and time of opening Price-Bid will be intimated in advance. In case tenderer want to modify the price bid he can submit the same before opening of the price bid as intimated by Executive Engineer (El.). This however, may be allowed only if there is any change in specifications/ items by the department during the technical scrutiny of the tender.

3.10 A tender will not be allowed to withdraw or modify any condition at a time after the technical bids have been accepted and the decision to open the price bid has been taken by the department.

3.11 The Part-III of the tender i.e. Price bid, (third envelope) along with revised price bid if any (if desired & allowed by the Department) will be opened by the Executive Engineer (E) in the presence of the representatives of the tenderers who wish to be present on the due date and time of opening of price bid.

3.12. The work to be awarded by this tender shall be treated as indivisible works contract.

4.0 Guarantee:

All equipments shall be guaranteed for a period of 12 months from the date of completion of work (final testing) or 18 months from date of actual supply of equipment at site whichever is earlier. Acceptance and taking over of the installation by the Department against unsatisfactory performance and / or breakdown due to defective design, material, manufacture, workmanship or installation. The equipment or component or any part thereof so found defective during the guarantee period shall be repaired or replaced free of cost to the satisfaction of the Engineer-in-Charge. In case it is felt by the department that undue delay is being caused by the contractor in doing this, the same will be got done by the department at the risk & cost of the contractor. The decision of Engineer-in-Charge in this regard shall be final.

5 Payment Terms

The following percentage of contract rates shall be payable against the stages of work shown herein.

	STAGE OF WORK	**MACHINERY & EQUIPMENT**	**ALL OTHER ITEMS**
1	After initial inspection (Wherever specified) & delivery at site in good condition on prorate basis	80%	70%
2	On completion of pro-rata installation	10%	20%
3	On commissioning and completion of successful running in period	5%	5%
4	On completion of major seasonal test	5%	5%

5.0 **Security Deposit**

Security Deposit shall be deducted from each running bill and the final bill to the extent of 5% of the gross amount payable subject to a maximum limit of 5% of the tendered value of work. The earnest money deposit shall be adjusted against the security deposit. The security deposit shall be released on the expiry of guarantee period stipulated in the contract.

6.0 Performance Guarantee

The successful tenderer shall submit an irrevocable performance guarantee of 5% of the tendered amount in addition to other deposits mentioned elsewhere in the contract for his proper performance of the contract agreement within 15 days of issue of letter of intent. The Guarantee shall be in the form of government securities or fixed deposit receipts or guarantee bonds of any scheduled bank or the state bank of India in the specified format. The performance guarantee shall be initially valid up to the stipulated date of completion

plus 60 days beyond. The bank guarantee shall be kept valid till the recording of completion certificate for the work by competent authority.

7.0 Rates

7.1 The rates quoted by the tenderer, shall be firm (exclusive of service tax) and inclusive of all taxes (Inclusive work and contract taxes), duties and levies and all charges for Packing, forwarding, insurance, freight and delivery, installation, testing, Commissioning etc. at site including temporary constructional storage, risk, overhead Charges General liabilities / obligations and clearance from concerned Authorities. However, the fee for these inspections shall be borne by the Department, on production of supporting documents.

7.2 Octroi duty shall not be paid separately but octroi exemption certificate can be furnished by the department on demand. However, the department is not liable to reimburse the octroi duty in case exemption certificate are not honoured by the concerned authorities.

7.3 Service tax shall be reimbursed separately on production of documentary proof.

8.0 Completion period

The completion period of **3** months indicated in the tender documents is for the entire work of planning, designing, supplying, installation, testing, commissioning and handing over the entire system to the satisfaction of the Engineer-in-charge.

9.0 Power supply, Water supply and Drainage

Power supply, Water supply shall be made available to the contractor by the department free of cost at only one point for installation. Drain trap in plant room shall be provided by department However contractor shall connect the drain pipe valve etc from equipment to drain trop.

10.0 Data Manual and Drawings to be furnished by the tenderer:

10.1 With Tender: The tenderer shall furnish along with the tender, detailed technical literature, pamphlets and performance data for appraisal and evaluation of the offer.

10.2. After award of work

The successful tenderer would be required to submit the drawing within 15 days of work for approval before commencement of installation.

10.3 The successful tenderer should furnish well in advance three copies of detailed Instructions and manuals of manufacturers for all items of equipment regarding installation, adjustments operations and maintenance i/c preventive maintenance & trouble shooting together with all the relevant data sheets, spare parts catalogue and workshop procedure for repairs, assembly and adjustment etc. all in triplicate.

11.0 Extent of work

11.1 The work shall comprise of entire labour including supervision and all materials necessary to make a complete installation such tests and adjustments and commissioning as may be required by department. The term complete Installation shall not only mean major items of the plant and equipments covered by specifications but all incidental sundry components necessary to complete execution and satisfactory performance of installation with all layout charts whether or not those have been mentioned in detail in the Tender document in connection with this contract.

11.2. Minor building works necessary for installation of equipment, foundation, making of opening in floors and restoring to their original condition, finish the necessary grouting etc. as required.

11.3. The work is turnkey project. Any item required for completion of project but left inadvertently shall be executed with-in the quoted rates.

12.0 Inspection and Testing:

Initial inspection at works and final inspection and testing at site shall be carried out as per chapter 17 of CPWD General Specification for HVAC works 2004 as amended to date.

13.0 Validity

Tenders shall be valid for acceptance for a period of 90 days from date of opening of price bid.

14.0 Compliance with Regulations & Indian standards, Indemnity & Insurance

14.1 All work shall be carried out in accordance with relevant regulation, both statutory and those specified by the Indian standards

15.0 Mobilization Advance: No mobilization advance shall be paid.

16.0 Insurance and Storage:

All consignments are to be duly insured upto the destination from warehouse to warehouse at the cost of contractor. The insurance covers shall be valid till the equipments handed over duly installed, tested and commissioned.

15.0 Verification of correctness of Equipment at Destination:

The contractor shall have to produce all the relevant records to certify that the genuine equipment from the manufacturers has been supplied and erected.

GENERAL SPECIFICATION FOR HVAC WORK

Name of work **C/o** IISER Mohali. SH: Providing Air-Conditioning at Stem cell, Virus lab, Tissue culture, FACS, confocal and Micro dissection lab.

1(a) The definition of terms used in these specifications shall be in accordance with IS: 3615.

1(b) Site Information

The tenderer should, in his own interest, visit the site and familiarize himself with the site conditions before tendering. For any clarification, tenderer may discuss with the Engineer-in-Charge.

1(c) Heat Load Calculations and Equipment Selection

i) The tenderer should also give the above heat load calculations wherever required separately for the areas served by each Unit in a air conditioning / heating system.

ii) The equipment selection shall be made on the basis of the above heat load calculations wherever required.

1(d) CONFORMITY WITH STATUTORY ACTS, RULES, STANDARDS AND CODES

i) All components shall conform to relevant Indian Standard Specifications, wherever existing, amended to date. A list of such standards is appended in Appendix `B'.

ii) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended to date.

1(e) SAFETY CODES AND LABOUR REGULATIONS

i) All the safety procedures outlined in the safety codes listed in Appendix-C shall be complied with.

ii) In respect of all labour employed directly or indirectly on the work for the performance of the air conditioning contractor's part of work, the contractor at his own expense, will arrange for the safety provisions as per the statutory provisions, B.I.S. recommendations, factory act, workman's compensation act, and instructions issued from time to time. Failure to provide such safety requirements would make the tenderer liable for penalty for each violation. In addition the Engineer-in-charge, shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost from the contractor.

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

1(f) WORKS TO BE ARRANGED BY THE DEPARTMENT

Unless otherwise specified in the tender documents, the following works shall be arranged by the Department:

i) Space for accommodating all the equipment and components involved in the work,

ii) False ceiling and/or return air enclosure excluding return air duct wherever provided as required.

iii) Power supply, Water supply and Drain points.

iv) Masonry ducts within and outside the building for carrying pipe lines and cables wherever specified.

v) Air-tight fire doors with minimum one hour fire rating for Air Handling unit rooms, fan rooms and other equipment rooms.

vi) Water proofing of floors of packaged unit rooms.

vii) Providing 15 amps power outlet within 2 meter reach of each single phase equipment at locations called for on air conditioning contractor's shop drawings.

viii) Providing wiring and earthing for sump pumps with pumps in plant room.

ix) Making openings in the walls/ floors/ slabs or modification in the existing openings wherever provided for carrying pipe line, ducts, cables etc

x) Providing sump pumps and necessary piping for drainage of packaged unit room at each level and other machine rooms located below ground level.

xi) Disposal of condensate drain from fan coil units beyond the condensate drain riser.

1(g) WORKS TO BE DONE BY THE CONTRACTOR

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

i) Foundations for equipments including foundation bolts and vibration isolation spring/pads,

ii) Support columns and beams for cooling towers,

iii) Suspenders, brackets and floor/ wall supports for suspending / supporting ducts and pipes,

iv) Suspenders and/or cable trays for laying the cables,

v) Excavation and refilling of trenches in soil wherever the pipes are to be laid directly in ground, including necessary base treatment and supports.

vi) Sealing of all floor slab / wall openings provided by the Department or contractor for pipes and cables, from fire safety point of view, after laying of the same.

vii) Painting of all exposed metal surfaces of equipments and components with appropriate colour as per para 1(q).

ix) Providing wooden/ metallic frames for fixing grills/ diffusers.

x) Making good all damages caused to the structure during installation and restoring the same to their original finish.

1(h) POWER SUPPLY, WATER SUPPLY AND DRAINAGE

i) Unless otherwise specified, 3 phase, 415 volts, 50 Hz power supply shall be provided by the department free of charge to the contractor at one point for installation at site. Termination switchgear however, shall be provided by the contractor. Further extension if required shall be done by the contractor.

ii) a) The power supply for testing and commissioning of the complete installation shall be made available by the Department free of charge to the contractor. For this purpose, the power supply shall be given at the main incomer unit of the main electrical panel (provided by the contractor) through U.G. cable, or bus trunking arrangement as specified in the contract. The termination of this feeder in the main incomer unit shall be the responsibility of the contractor and nothing extra shall be paid on this account.

b) Unless otherwise specified in the contract, further power distribution to the various equipments shall be done by the contractor.

iii) Where the power supply has to be arranged by the Department at more than one point as per the terms of the contract, the termination of all such power feeders in the incomer of respective control panels (provided by the contactor) shall be the responsibility of the contractor.

iv) The contractor shall not use the power supply for any other purpose than that for which it is intended for. No major fabrication work shall be done at site. Power shall be used only for welding / cutting works. The power supply shall be disconnected in case of such default and the contractor shall then have to arrange the required power supply at his cost.

v) Wherever there is a possibility of lower supply voltage, which does not allow motors to be operated, necessary voltage correction devices like HT voltage regulator/ ON- Load tap changer/ Servo Stabilizer etc may be provided to ensure proper voltage.

c) Power supply shall also be backed by suitable standby DG set. It is necessary to provide stand by supply to fan motors, to ensure air circulation in air conditioning areas when the AC plant is not working due to non availability of normal electrical supply. Additionally where the air conditioning is a functional/ critical requirement such as hospitals, computer centers, labs etc, provision shall be made by the department for operation on standby power supply.

1(i) WATER SUPPLY

i) Water supply shall be made available to the contractor by the Department free of charge at only one point for installation. Further extension if required shall be done by the contractor.

ii) Water shall be made available by the Department free of charge in make up water tank near the cooling tower, AC plant room, AHU room, expansion tank, hot water generator, air washer, etc. as required for testing and commissioning. Further connection from make up water tank to cooling tower shall be carried out by the contractor and shall be separately measured & paid for as per contract.

iii) Water analysis should be obtained of the water available at site and if required water softening plant may be provided.

1(j) DRAINAGE

i) Drain traps in A.C. plant room, AHU room, Air washer room, hot water generator and near cooling tower shall be arranged by the department.

ii) All drainage arrangements from the drain traps in the A.C. plant room, AHU room, air washer room, hot water generator room etc to the drain line shall be arranged by the Department as required.

iii) Piping Connections from the equipment to the drain trap including providing valves at the drain points shall be done by the contractor. These items of work shall be separately measured and paid as per contract.

1(k) <u>MACHINERY FOR ERECTION</u>

All tools and tackles required for unloading / handling of equipments and materials at site , their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

1(l) COMPLETENESS OF THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK

i) Completeness of the tender

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

ii) Submission of program

Within fifteen days from the date of receipt of the letter of acceptance, the successful tenderer shall submit his program for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in-Charge. This program shall be framed keeping in view the building progress. Items like ducting, piping etc. that directly affect the building progress shall be given priority.

iii) Submission of Drawings

The contractor shall submit the drawings to the Engineer-in-Charge as per para 1.18.2 for approval before start of work.

iv) Commencement of Work

The contractor shall commence work as soon as the drawings submitted by him are approved.

1(m) DISPATCH OF MATERIALS TO SITE AND THEIR SAFE CUSTODY

The contractor shall dispatch materials to site in consultation with the Engineer-in-Charge. Suitable lockable storage accommodation shall be made available free of charge temporarily. Watch & ward however, shall be the responsibility of contractor. Program of dispatch of material shall be framed keeping in view the building progress. Safe custody of all machinery and equipment supplied by the contractor shall be the responsibility of the contractor till final taking over by the department.

1(n) CO-ORDINATION WITH OTHER AGENCIES

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

1(o) QUALITY OF MATERIALS AND WORKMANSHIP

i) The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.

ii) The entire work of manufacture/fabrication, assembly and installation shall conform to sound engineering practice. The entire installation shall be such as to cause minimum transmission of noise and vibration to the building structure.

iii) All equipments and materials to be used in work shall be manufactured in factories of good repute having excellent track record of quality manufacturing, performance and proper after sales service.

1(p) CARE OF THE BUILDING

Care shall be taken by the contractor during execution of the work to avoid damage to the building. He shall be responsible for repairing all such damages and restoring the same to the original finish at his cost. He shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.

1(q) COLOUR SCHEME FOR THE EQUIPMENTS AND COMPONENTS

i) Colour scheme for equipment like chilling unit, pumps, AHUs, cooling tower etc shall be as per manufacturer’s standard colour scheme.

ii) The scheme of colour code painting of pipe work services for air conditioning installation shall be as per National building code and is indicated below:

Description	Ground colour	Lettering colour	First colour band
Condenser water piping	Sea Green	Black	French Blue
Chilled water piping	Sea Green	Black	Black
Central heating piping Below 60 deg C	Sea Green	Black	Canary Yellow
Central heating piping 60 deg C to 100 deg C	Sea Green	Black	Dark Violet
Drain pipe	Black	White	
Vents	White	Black	
Valves and pipe line fittings	White with black handles	Black	
Belt guard	Black & Yellow diagonal strips		
Machine Bases, Inertia Bases and Plinth	Charcoal Grey		

iii) Colour bands shall be 150mm wide, superimposed on ground colour to distinguish type and condition of fluids. The spacing of band shall not exceed 4.0m.

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

High temperature Hot water : HTHW

Medium temperature Hot water: MTHW

Low temperature Hot water : LTHW

Chilled water : CHW

Condenser water : CDW

Steam : ST

Condensate : C

1(r) INSPECTION AND TESTING

i) Initial inspection of materials & equipments at manufacturer's works as per details will be done by the engineer-in-charge or his representative. For item/ equipment requiring initial inspection at manufacturer's works, the contractor will intimate the date of testing of equipments at the manufacturer's works before dispatch. The contractor shall give sufficient advance notice regarding the dates proposed for such tests to the department's representative(s) to facilitate his presence during testing. The Engineer-in-charge at his discretion may witness such testing. Equipments will be inspected at the manufacturer/ authorised dealer's premises, before dispatch to the site by the contractor.

ii) The department also reserves the right to inspect the fabrication job at factory and the successful tenderer has to make arrangements for the same.

iii) The materials duly inspected by engineer-in-charge or his authorised representative shall be dispatched to site by the contractor.

1(r1) Final Inspection & Testing

Final Inspection & testing will be done by the Engineer-in-Charge or his representative as per details indicated in Specifications for HVAC works.

1(r2) Safety measures

All equipments shall incorporate suitable safety provisions to ensure safety of the operating personnel at all times. The initial and final inspection reports shall bring out explicitly the safety provisions incorporated in each equipment.

1(r3) RUNNING IN PERIOD & DATE OF ACCEPTANCE

i) After the installation work has been completed by the contractor, he will conduct tests and make adjustments as may be necessary to satisfy himself that the plant including low side equipments is capable of continuous running. There after he will offer to the department a running-in period of 7 days subject to a minimum aggregate of 120 hrs at his cost. The duty cycle of the plant during this running in period shall be same as that specified in the tender documents. In case of multiple compressor installations, all the compressors should be run by rotation. The plant will be operated and a log of all parameters will be maintained during this period. The contractor will be free to carry out necessary adjustments etc. during this period without stopping the plant. Record of inside conditions will be made during this period to check the same are as per NIT requirements. The plant will be said to have successfully completed the running-in-period, if no break down or abnormal/ unsatisfactory operation of any machinery occurs during this period. After this the plant will be made available for beneficial use. After the plant has operated without any major break down/ trouble and inside conditions are maintained as per NIT requirements for the above specified running in period, it shall be taken over by the department subject to guarantee clause mentioned below. This date of taking over of plant after trouble free operation during the running in period shall be the date of acceptance.

ii) Any loss of refrigerant or oil during the running in period shall be made good by the contractor free of charge.

iii) Capacity test of the chilling unit & other major equipments shall be carried out as and when conditions become stabilized as per instructions of engineer in charge.

iv) Seasonal testing may be carried out as & when outside conditions become suitable.

1(s1) When the major seasonal test cannot be carried out on commissioning of the installation due to any reason not attributable to the contractor, the installation will he handed over to the Department for beneficial use after completion of successful running in test of 7 days subject to a minimum aggregate of 120 hours as per para 1(r3) above. The balance payment shall be released to the contractor on his furnishing a bank guarantee in the specified format from a scheduled bank for an equivalent amount. The bank guarantee shall be valid for a period of 6 months. However it will be extended till the successful completion of the major seasonal test. This bank guarantee shall be independent of the one furnished for performance guarantee.

1(s2) The following shall be considered major seasonal test for the purpose of the above payment terms: -

a)	Air-conditioning system	:	Summer or monsoon
b)	Central heating system	:	Winter
c)	ETAC	:	Summer

1(t) TENDER DRAWINGS, DRAWINGS FOR APPROVAL & COMPLETION DRAWINGS

The drawings appended with the tender documents are intended to show the areas to be conditioned, space allotted for various equipments, tentative duct, cable and pipe routes. The equipments offered shall be suitable for installation in the spaces shown in these drawings.

1(t1) Drawings for approval on award of the work

The contractor shall prepare & submit three sets of following drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipments/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

a) Lay out drawings of the equipments to be installed in various rooms such as plant room, AHU rooms, hot water generator room, cooling tower and other equipments.

b) Drawings including section, showing the details of erection of entire equipments including their foundations, water basin for the cooling towers / air washers, etc.

c) Plumbing drawings showing the layout of entire piping, dia & length of pipes, valves and isometric drawings showing connections to various equipment.

d) Ducting drawings showing sizes, locations of dampers, grilles & diffusers.

e) Electrical wiring diagrams for all electrical equipments and controls including the sizes and capacities of the various cables and equipments,

f) Dimensioned drawings of all electrical and control panels,

g) Drawings showing the details of all insulations and vapour barrier works,
h) Drawings showing details of supports for pipes, cable trays, ducts etc.
i) Any other drawings relevant to the work.

1(u) Completion Drawings

Three sets of the following laminated drawings shall be submitted by the contractor while handing over the installation to the Department. Out of this one of the sets shall be laminated on a hard base for display in the A.C. plant room. In addition one set will be given on compact disc.

a) Plant installation drawings giving complete details of all the equipments, including their foundations,

b) AHU room installation drawings.

c) Plumbing layout drawings including insulation giving sizes and lengths of all the pipes and the sizes and locations of all types of valves, and including isometric drawings for the entire piping including the pipe connections to the various equipments and insulation details wherever required.

d) Duct layout drawings with their sizes and locations, and sizes and locations of all dampers, grills & diffusers.

e) Line diagram and layout of all electrical control panels giving switchgear ratings and their disposition, cable feeder sizes and their layout,

f) Control wiring drawings with all control components and sequence of operations to explain the operation of control circuits,

1(v) AFTER SALES SERVICES

The contractor shall ensure adequate and prompt after sales service in the form of maintenance, spares and personnel as and when required and shall minimise the breakdown period. In case of equipment supplied by other manufacturers the firm shall furnish a guarantee from the manufacturer for the same before the plant is taken over.

1(w) DOCUMENTS TO BE FURNISHED ON COMPLETION OF INSTALLATION

Three sets of the following documents shall be furnished to the department by the contractor on completion of work:-

a) Completion drawings as per Specifications for HVAC Works.

b) 3 sets of manufacturer's technical catalogues of all equipments and accessories.

c) Operation and maintenance manual of all major equipments, detailing all adjustments, operation and maintenance procedure.

BASIS OF DESIGN AND SCHEME

1 AMBIENT CONDITIONS

Outdoor Design Conditions

The following design conditions have been considered.

Season		DBT (^{O}C)	WBT (^{O}C)
Summer	:	43.3 ($110\ ^{O}$F)	23.8 ($75\ ^{O}$F)
Monsoon	:	35 ($95\ ^{O}$F)	28.3 ($83\ ^{O}$F)
Winter	:	7.2 ($45\ ^{O}$F)	5 ($41\ ^{O}$F)

Indoor Design Conditions:

Summer / Monsoon/ winter	DB : 24 $\pm$ 1 Deg C (75 $\pm$ 2 Deg F) RH : Less than 60%

2 Design Data: Following design parameters are being considered for calculating the heat loads.

Occupancy		15 Nos
Lighting		1.5 Watts / Sqft (Fluorescent)
Outdoor Fresh Air addition rate		1 ACPH
Equipment load		5 KW
Area		As per layout attached

3. SYSTEM DESCRIPTION

The proposed air conditioning system shall consist of Air-cooled condensing units. These units shall suitable capacity Air Handling units so as to maintain the desired conditions. The outdoor units shall be connected with AHU thru heavy grade Refrigerant piping adequately sized. All motors for air-conditioning system shall be energy efficient type, suitable for 415 $\pm$ 10% / 220$\pm$ 6% volts incoming power supply.

Condensing units shall be placed on epoxy coated MS frames and provided with anti-vibratory supports. All foundations shall be protected from mechanical damage by providing epoxy coated angle nosing.

All ducts shall be factory fabricated out of galvanized sheet steel (GSS) for long life and as per fire norms. The conditioned air shall be distributed thru air registers and diffusers as shown in the drawings. All ducts shall be insulated with closed cell nitrile rubber. AC units shall also be tripped in case of emergency thru fire panel.

Clean room shall be maintained at Class 10000 and is designed at 75 ACPH. This area shall have 4 stage filtration with terminal filters. This area shall be surround by semi clean area

which will be maintained at class 100000 with 3 stage filtration. The dirty corridor shall also be air-conditioned with normal filtration.

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DESIGN PARAMETRS

Given blow are some design parameters which should be followed in addition to those given in various sections of technical specifications enclosed

AIR HANDLING UNITS

a) Maximum Face Velocity across cooling coil MPM	:	152.43
b) Maximum Face Velocity across Pre filters MPM	:	152.43
c) Fan outlet velocity (maximum) MPS	:	9.5
d) Maximum fan speed (forward curved)	:	1000 RPM
e) Maximum fan motor speed	:	1450 RPM

DUCTING WORK

a) Method of Duct Design	:	Equal friction method/ constant friction method
b) Maximum Air Velocity in supply air duct	:	450.00
c) Maximum Air Velocity in return air duct	:	305.00
d) Friction loss in duct (max) MM wg in 100 Mt run	:	10
e) Maximum Velocity at supply air grill outlet MPM	:	150.00

INSULATION

Maximum temperature rise in the supply air duct from Air Handlers outlet to farthest outlet 1.1Deg C

APPLICABLE STANDARDS AND CODES

TERMS AND DEFINATIONS

The following terms have been used in the tender specifications and drawings etc.

ISI	Bureau of Indian standards
ASHRAE	American society of Heating Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BS	British Standard
CMH	Cubic Meter per hour
USGPM	US gallons per Minute
RPM	Rotations per minute
BTU/Hr.	British Thermal unit per hour
Kcal/ Hr	Kilo calories per hour
SAG	Supply air Grill
RAG	Return Air Grill
FD	Fire damper
FAD	Fresh air damper
DP	Drain Point
SAD	Supply air diffuser
RAD	Return air Diffuser.

LIST OF BUREAU OF INDIAN STANDARDS CODES

Following relevant IS codes shall apply read in concurrence with there latest amendments.

IS:226-1975	Specification for structural steel
IS:277-1992	Specification for galvanised sheet (plain and corrugated)
IS:325-1978	Specification for three phase induction motors
IS:655-1963	Specification for metal duct
IS 659-1964 (1991)	Safety code for air-conditioning (resived)
IS:660-1963 (1991)	Safety code for mechanical refrigeration
IS:800-1984	Code of practice for general construction in steel
IS:808-1964	Specification for rolled steel beam channel and angle section
IS:816-1969	Code of practice for metal arc welding for general purpose in mild steel
IS:823-1964	Code of procedure for manual metal arc welding of mild steel
IS:1554-(Part 1) –1976	Specs for PVC insulated (heavy duty electrical cables)
IS:2253-1974	Designation for types of construction and mounting arrangement of rotating electric machine.
IS:2312-1967	Specs for propeller type AC ventilating fans
IS:2379 - 1963	Colour code for the identification of pipelines
IS : 3103-1975	Code of practice for Industrial Ventilation
IS 4064 - (Part -II) 1978	Specific requirements for the direct switching of individual motors.
IS: 4736 - 1968	Hot-dip zinc coatings on steel tubes
IS: 4894-1987	Test Code for Centrifugal Fan.
IS : 7240-1981	Application & Finishing of thermal insulation material
IS:8544 (Part-I to IV)1979	Starters
IS:9224 (Part II) - 1979	HRC cartridge fuse links upto 650 volts.
IS:3069-1965	Glossary of terms, symbols and unit relating to thermal insulation material
IS:3346-1980	Method for the determination of thermal conductivity thermal I insulation materal (two slab, guarded hot plate method)
IS:3588-1966	Specification for electric axial flow fans

IS:3724-1966	Specs for cartridge type heating elements (non embedded type)
IS:4158-1967	Specs for solid embedded type electric heating elements
IS:4691-1984	Degree of protection provided by enclosure for rotating electrical machine
IS:4722-1968	Specs for rotating electrical machine
IS:4729-1968	Measurement and evaluation of vibration of rotating electrical machine.
IS:4831-1968:	Recommendation on units and symbols for Refrigeration
IS:4894-1987	Specs for centrifugal fans
IS:5111 -1993	Testing of Refrigerating compressors.
IS:6272-1971:	Specs of industrial cooling fans
IS:7616-1975	Method of testing panel type air filters for air conditioning and ventilation purposes
IS;8623 1977	Specs of factory built switch / control section.
IS:8623(Part3) 1993:	Specs for low voltage switchgear and control gear assemblies
IS: 8789- 1978	Values of performance characteristics for three phase induction motor
IS-13947 (Part-1)1993	Specs for low voltage switchgear and control gear.

In case of any revision in above BIS code the REVISED one shall only be applicable.

GENERAL MECHANICAL REQUIREMENTS

1 This chapter deals with the general mechanical requirements specifically applicable to HVAC. The additional requirement given in any chapter is in addition to the bare minimum stated in this chapter and shall be complied with.

2 SUBMITTALS

Under provisions of the NIT sample approval for all major items like grills, diffusers, valves, insulation, sheet etc is necessary before the commencement of the project. The products mentioned in the Approved list of manufacturers shall only be acceptable. In case of any alternate make is required to be used the same will have to be approved by the customer/engineer in charge with proper quality and rate justification as per the mode of approval mentioned in the list. Shop drawings and product data grouped to include complete submittals of related Systems, products, and accessories in a single submittal. Shop Drawings shall be based on the actual duct routes after the site survey, details of concrete pads and foundations for the various equipments, Layout of the AHU including dimensions of the room / boxing with inspection window dimensions, the foundations and the sizes and all necessary construction details required on site, location of the allied equipments and the requirements from other agencies, trench locations if any, Sump location and size, sleeve location if any, fresh air / exhaust air locations, location of wall mounted equipment (If any) and any structural inputs.

3 BROCHURES

Submit manufacturer’s product data and brochure including complete description of the item with illustrations, rating charts, accessories, dimensional data, capacities stated in the terms specified in the NIT and Performance curves, wherever applicable like fans and pumps.

4 REGULATORY REQUIREMENTS

Liaison / Approvals from the bodies mentioned below (or any other), if required shall be taken by the contractor on behalf of the client and at his own cost. BIS / Local Fire Authority / LOCAL CODES .

5 PROJECT / SITE CONDITIONS

- Mechanical layouts indicated on drawings are diagrammatical. Co-ordination (final) shall be required with other trades prior to installation. Install all works as shown on the drawings, unless prevented by project conditions.
- Prepare drawings showing proposed rearrangement of work to meet the project conditions. Obtain permission from of engineer in charge before proceeding.
- Place anchors, sleeves and supports prior to pouring concrete on installation of masonry works.
- Keep roads and site clear of debris and scrap.

6 GENERAL INSTALLATION FEATURES

- Piping / ducting installation requirements are specified in other section. The Drawings indicate the general arrangement of piping, valves, fittings, ducts and specialties. The following are specific connection requirements:
- Arrange piping installations adjacent to units to allow unit servicing and maintenance.

- Connect piping to all equipment with flanges enabling easy removal of the coil.
- Connect condensate drain pans using drain pipe and extend to nearest floor drain. Construct deep trap connection to drain pan and install cleanouts at changes in direction.
- Make final duct connections with flexible connections.

  Connect unit components to ground in accordance with the National Electrical Code

AIR COOLED CONDENSING UNITS

1. SCOPE

The scope of this section comprises of the supply, erection, testing and commissioning of Air cooled condensing machines conforming to specifications given hereunder and in accordance with the requirements of drawings and schedule of quantities.

2 TYPE

The Units shall be complete with single/ multiple SCROLL compressors, blower & motor assembly, condensors, and internal wiring and shall be enclosed in an attractive cabinet.

3 CAPACITY

Actual refrigeration capacity of Units shall be as given in schedule of quantities.

4 COMPRESSOR

The compressor shall be for heavy duty specifically designed for high head pressures. Compressors shall be of SCROLL, Hermetically sealed with gas cooled motor. The motor and compressors shall be enclosed in a single Hermetic casing. The compressor shall be suitable for R-22 refrigerant and shall be mounted in the indoor units.

5 CONDENSORS

Condensor shall be of air cooled, fitted with integral finned copper tubes of 12 mm O.D. Condensor shall be manufactured to ASME code for unfired pressure vessels. Working pressure for refrigerant side shall be for refrigerant used. Condensors shall be complete with the following accessories:

- Hot gas inlet connection, liquid outlet connection, relief valve, purge valve, fusable plug, air vents etc. Shall be salt sprayed.
- Any other standard accessories necessary for equipment supplied.

6 TESTING

Equipment capacity in Tons of refrigeration shall be computed from the temperature readings. The computed results should tally with the specified capacities. All instruments, services needed for the tests required shall be furnished by the contractor.

7 PAINTING

All the equipment including mounting frame shall be painted with two coats of approved enamel paint.

SPECIFICATIONS FOR AIR HANDLING UNITS

1. SCOPE

This section of the specification covers the supply, installation, testing and commissioning of double skin construction air handling units along with its accessories, conforming to these specifications and in accordance with requirement of the 'Schedule of Quantities', Drawings and 'Technical Schedule of Equipment'.

2. CAPACITY

The air handling capacities, maximum motor HP, static pressure shall be as shown on Drawings and as indicated in 'Schedule of Quantities'.

3 HORIZONTAL FLOOR MOUNTED

The Horizontal floor mounted air handling units shall be double skin modular, draw through type comprising of various sections such as mixing chamber (wherever return air and fresh air are ducted.), pre filter section, chilled water coil section, fan section supply air plenum as per details given in Drawings and Schedule of Equipment.

3.1 AHU HOUSING / CASING:

The AHU housing shall be of double skin construction with main structure made of extruded aluminum hollow sections. The panels shall be double skin sandwich type with 0.6 mm pre painted GSS/ pre-plasticised on the outside and 0.6 mm galvanized sheet inside with 25 mm thick PUF insulation material injected in between. These panels shall be screwed with soft rubber gasket fixed in built in groove of aluminum frame in between to make the joints airtight. Framework for each section shall be joined together with soft Neoprene rubber gasket in between to make the joints airtight. Suitable airtight access doors /panels with nylon hinges and locks shall be provided for access to various sections for maintenance. The entire housing shall be mounted on roller-formed GSS channel framework having pressure die cast aluminum jointers.

3.2 Drain Pan

The drain pan shall be of 18 G aluminum/stainless steel with necessary slope to facilitate fast removal of condensate. It shall be provided with drain connection of suitable size complete with 25 mm rigid insulation. Necessary arrangement will be provided to slide the coil in the drain pan. The drain pan shall be insulated with 12 mm thick close cell Nitrile insulation (self adhesive) or equivalent.

3.3 Cooling / Heating Coil

The chilled /hot water coil shall be of seamless copper tubes not less than 27 G thick and 12mm OD. Coil face areas shall be such as to ensure rated capacity from each unit and such that air velocity across each coil shall not exceed 150 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The fins shall be spaced by collars forming integral part of the fins. The tubes shall be staggered in the direction of airflow.

The fins shall be uniformly bonded to the tubes by mechanical expansion of the tube for minimum thermal contact resistance with fins. Fin spacing shall be 11to 13 FPI. The coils shall be tested against leaks at a hydraulic pressure of 21-kg/sq. cm. This pressure shall be maintained for a period of at least 2 hours. No drop should be observed indicating any leaks. The water headers shall be complete with water in /out connections, vent plug on top and drain at bottom and designed to provide water velocity between 2 to 6 FPS.

3.4 Fan Section with Fan

The fan shall be Forward / Backward curved, double inlet double width type. The wheel & housing shall be fabricated from heavy gauge galvanised steel. The fan impeller shall be mounted on a solid shaft supported to housing with angle iron frame & pillow block heavy-duty ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller & fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 600 MPM. Fan housing with motor shall be mounted on a common extruded aluminum base mounted inside the air handling housing on anti vibration spring mounts or cushy foot mounts of at least 90% vibration isolation efficiency. The fan outlet shall be connected to casing with the help of fire retardant double canvas or Neoprene rubber of imported Origin. The fan shall be selected for a noise level of less than 75 DB (A) at one meter distance.

3.5 Filter Section

Each unit shall be provided with a factory assembled filter section containing synthetic media washable air filters with efficiency of 90% down to 10-micron particle size. Filters shall have aluminum frame. Filter face velocity shall not exceed 150 meters per minute. Filter shall fit so as to prevent by pass. Holding frames shall be provided for installing number of filter cells in banks. These cells shall be held within the frames by sliding the cells between guiding channels.

4. FRESH AIR INTAKES

Extruded aluminum construction duly anodized fresh air louvers with bird screen and extruded construction dampers shall be provided in the clear opening in masonry walls of the air handling unit room having at least one external wall. Fresh air louver, damper, pre filters, ducts and fresh air fan with speed regulator (wherever specified in 'Schedule of Quantities') shall be provided. Fresh air dampers shall be of the interlocking, opposed blade louver type. Blades shall be free from rattle. Damper shall be similar to those specified in 'air distribution'. Fresh air fans and fresh air intakes shall be as per the requirements of 'Schedule of Quantities'.

5. ACCESSORIES

Each air handling unit shall be provided with manual air vent at highest point in the cooling / heating coil. In addition, the following accessories may be required at air handling units. Their detailed specifications are indicated in individual sections and quantities separately identified (for items a to i) in 'Schedule of Quantities'.

a. Stem type thermometer at each AHU coil inlet and outlet with tubing and gauge cocks and specification as per the section, 'Automatic Controls and Instruments'
b. Union and condensate drain piping from the unit up to the drain trap as described in section piping.
c. Cooling /heating thermostat as per section 'Automatic Controls and Instruments' shall be located in return air stream.
d. Flexible connection between the fan outlet and duct.
e. Vibration isolators of at least 90% efficiency.

6 SAFETY FEATURES

Each handling unit must have safety features as under:-

a. The fan access door must have micro switch interlocked with fan motor to enable switching off the fan motor automatically in the event of door opening. The access door shall further have wire mesh screen as an added feature, bolted on to the unit frame.
b. Fan and motor base shall be properly earthed from the factory.

c. All screws used for panel fixing and projecting inside the unit shall be covered with PVC caps to avoid human injury.

7. DRIVE

Fan drive shall be 3phase-squirrel cage totally enclosed fan cooled motor suitable for 415 ± 10%V, 50 HZ AC supply. Motor shall be specially designed for quiet operation and motor speed shall not exceed 1440 RPM. Drive to fan shall be provided through belt drive arrangement with required no. of belts for power transmission without slippage. Belts shall be of oil resistant type of approved make only.

8 DESIGN DATA FOR AIR HANDLING UNITS

- Fan outlet velocity shall not exceed 600 MPM.
- The air velocity across coil shall not exceed 150 MPM.
- The air velocity across air pre filter shall not exceed 150 MPM.

Motor ratings are only tentative and shall be suitable for the duty but not less than the specified HP. The motor shall be selected with a safety factor of at least 15% over and above the brake power. The AHU fan shall be selected for static pressure as indicated in 'Schedule of Quantities'.

9. INSTALLATION

Air Handling Unit shall be installed to permit the removal of all the parts of AHU for any maintenance work without dismantling other equipment such as plenum, pipes, ducts etc. Air handling unit installation shall be carried out as per manufacturer's recommendation and mounted on serrated rubber pads with proper hanging arrangement. The serrated rubber pads shall be in two layers with 16G GI sheet sandwiched in between.

10. PERFORMANCE DATA

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

11. TESTING

Cooling/Heating capacity of various air-handling unit models shall be computed from the measurements of airflow and dry and wet bulb temperatures of air entering and leaving the coil.

Flow measurements shall be by anemometer and temperature measurements by accurately calibrated mercury in glass thermometer. Computed result shall conform to the specified capacities and quoted ratings. Consumption shall be computed from measurements of incoming voltage and input current.

SPECIFICATIONS FOR PIPING

1 SCOPE

All piping work shall conform to quality standards and shall be carried out as per specifications and details given hereunder.

2. **Piping :**

2.1 **Drain Piping: PPRC Pipes**

2.1.1 The drain piping shall be PN16 grade PPRC and laid in continuous slope.

2.1.2 The fittings shall be of PN25 grade of equal forged connections.

2.1.3 Pipe crosses shall be provided at bends, to permit easy cleaning of drain line.

2.1.4 The drain line shall be provided upto the nearest drain trap and pitched towards the trap.

2.1.5 Drain lines shall be provided at all the lowest points in the system, as well as at equipment, where leakage of water is likely to occur, or to remove condensate and water from pump glands.

2.3 **Copper Piping :**

2.3.1 Seamless soft copper tubing, type L shall be used to make connections to equipment, wherever required or specified.

2.3.2 Flare fittings e.g. flare nuts, tees, elbows, reducers etc. shall all be of brass.

2.4 **Refrigerant Piping :**

Refrigerant piping shall be Copper tube shall be with heavy class seamless steel pipe conforming to IS 1239 schedule 40. Fittings like bends, tees, shall be of copper or brass for copper piping. For bigger sizes bends, tees etc shall be steel butt-welded type and shall be suitable for working pressure as of refrigerant piping. Welded joints shall be used for steel pipes and brazed joints for copper pipes. For small lines such as gauge connections, equalizer lines of expansion valve etc flared fittings shall be used. 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. Piping shall be installed with adequate number of bends / loops to ensure flexibility for minimising vibrations. Necessary isolating materials like rubber and felt should be provided so as to reduce vibration.

While installing the piping adequate clearance between pipes should be provided for insulation wherever specified. Piping shall be pitched to 4mm for every metre in the direction of refrigerant flow. Necessary loops and bends shall be incorporated in the piping to ensure proper oil drainage to the compressor even under partial load conditions. Brazing of copper tubing shall be done with silver solder. Flanged joints wherever used shall be provided with gaskets suitable for use with halogenated hydrocarbon refrigerants.

All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before jointing 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. Subsequently, it shall be thoroughly blown out using nitrogen. System shall hold the pressure for

a period of 24 Hours without revealing any leaks . The system shall then be de-hydrated by drawing vacuum which shall be maintained for 24 Hrs.

After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using nitrogen at pressure of 20Kg per sq.cm and 10 Kg per sq.cm (lowside). 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 mentioned below:

Pipe Size in mm(OD)	**Wall Thickness in mm**
54.1	1.5
41.3 – 34.9	1.3
28.6 – 25.4	1.2
22.2 – 15.9	1.0
12.7 - 6.4	0.8

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.

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 Class I as specified in BOQ.

b. 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.

SPECIFICATIONS FOR AUTOMATIC CONTROLS AND INSTRUMENTS

1. SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of automatic controls and instruments conforming to these specifications and in accordance with requirement of drawings and 'Schedule of Quantities'

2. PRODUCTS

2.1 **Thermostats** shall be electrical mode, fixed differential type with sensing element located in the return air stream.

3. INSTRUMENTS

3.1 **Thermometer**: Thermometers shall be dial type 100 mm dia or V form industrial type. Body shall be aluminum alloy, anodized gold colored surface. The casing shall be adjustable sideways for reading from the front. The glass capillary shall be triangular in shape with blue mercury filled in glass for better visibility. Scale of reading shall be of the range 0 deg C TO 60 deg C & +32 deg F to 150 deg F. Graduation of scale shall be 1 deg in both readings. Ranges of scales shall be 30-90 degrees F (0-50 deg C) for all conditioning applications of cooling only.

Thermometer shall be suitable for 15mm connection. Thermometer for chilled water shall be with long stem so that thermometer is removable without damaging the insulation ms socket to be welded on pipes shall be provided with thermometer. Thermometer shall be installed of chilled water supply and return at each air handling unit, supply and return of each chiller, condenser.

3.2 **Pressure gauge**: shall be installed on suction header and at discharge side of each pump in the chilled water supply and return at each air handling unit, at inlet and outlet of each chiller. Suction side gauge at pump suction header shall be compound gauge with 150 MM dia, range 75 cm vacuum to 10 kg pressure. Discharge side gauge at pumps and at all other locations shall be 150mm range 0-10 kg per sq cm (0-150 PSI) Pressure

SPECIFICATIONS FOR SHEET METAL WORKS

1. SCOPE

The scope of this section includes supply, fabrication, installation & testing of all sheet metal ducts as per specifications & drawings. Except as otherwise specified all ductwork and related items shall be in accordance with these specifications. Duct work shall mean all ducts, casings, dampers, access doors, joints, stiffeners, hangers & all accessories.

2. DUCT MATERIALS

2.1 The ducts shall be fabricated from galvanized steel sheets class VIII - Light coating of Zinc conforming to ISS: 277-1962 (REVISED) with accompanying Mill test Certificates. Galvanizing shall be of 120gms/sq.m. (total coating on both sides). In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

Only new, fresh, clean (unsoiled) and bright GI / Aluminum sheets shall be used. The Owner / Consultants reserve the right to summarily reject the sheets not meeting these requirements. Fabrication of ducts shall be through Lock forming machines.

In case of factory fabricated duct the G.I. raw material should be used in coil-form (instead of sheets) so as to limit the longitudinal joints at the edges only irrespective of cross-section dimensions

3 SPECIFICATIONS FOR SITE FABRICATED DUCING

All duct work, sheet metal fabrication unless otherwise directed, shall strictly meet requirements, as described in IS: 655-1963 with Amendment-I (1971 Edition)

Longer size of Duct	Sheet Thickness GI (MM)	Type of Joints	Bracing
Up to 750	0.63	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	-
751-1000	0.80	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	25X25X3 MM @ 1M
1001-1500	0.80	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	40x40x5 MM @1M
1501-2250	1.00	50x50x5 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3mm@ 1.2m to be braced diagonally.
2251 & above	1.25	50x50x6 mm angle iron frame with 10 mm Dia nuts & bolts at 125 mm center	40x40x3mm @ 1.6m diagonally braced

Ducts larger than 450 mm shall be cross broken, duct sections up to 1200 mm length may be used with bracing angles omitted.

Changes in section of ductwork shall be affected by tapering the ducts with as long a taper as possible. All branches shall be taken off at not more than 45 Deg. Angle from the axis of the main duct unless otherwise approved by the Engineer-in-Charge.

All ducts shall be supported from the ceiling/slab by means of M.S. rods of 10 MM Dia with M.S. angle at the bottom of size 40 mm x 40 mm x 6 mm for sizes up to 1500 mm at

3 m intervals. Above size 1500 mm upto 2250, support shall be provided with 10 mm dia. MS rod and MS angle size 50 mm x 50 mm at bottom at 2.5 m intervals. Above size 2250 mm support shall be provided with 12 mm dia MS rod and MS angle size 50 mm x 50 mm at bottom

3. INSTALLATION

All ducts shall be fabricated and installed in workman like manner, generally conforming to relevant BIS codes. Round exposed ducts shall be die formed for achieving perfect circle configuration

Ducts so identified on the drawing shall be acoustically lined and thermally insulated as described in the section 'Insulation' and as indicated in 'Schedule of Quantities. Duct dimensions shown in drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in 'Schedule of Quantities'.

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

All exposed ducts upto 60 cm width within conditioned spaces shall have slip joints. The internal ends of the slip joints shall be in the direction of airflow. Ducts and accessories within ceiling spaces visible from air-conditioned areas shall be provided with two coats of matt black finish paint.

Change in dimensions and shape of ducts shall be gradual. Air turns shall be installed in all vanes arranged to permit the air to make the turn without appreciable turbulence.

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

All sheets metal connections, partitions and plenums required to confine the flow of air to/ through the filters and fans shall be constructed of 18 Gauge GSS thoroughly stiffened with 25mm x 25mm x 3mm angle iron braces and fitted with all necessary inspection doors as required to give access to all parts of the apparatus. Doors shall be not less than 45cm X 45cm in size.

Plenums shall be panel type and assembled at site. Fixing of MS angle iron flanges of duct pieces shall be with rivet heads inside i.e. Towards G.S. sheet and riveting shall be done from outside.

Rubber gasket 3 mm thick shall be used between duct flanges and between duct and duct supports instead of felt in all ducting installation for complete sealing.

During the construction, the Contractor shall temporarily close duct openings with sheet metal covers to prevent debris-entering ducts and to maintain opening straight and square, as per direction of Engineer-in-Charge.

Great care should be taken to ensure that the ductwork does not extend outside and beyond height limits as noted on the drawings.
All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be tight and shall be made in the direction of airflow.

The ducts shall be reinforced where necessary, and must be secured in place so as to avoid vibration of the duct on its support.

All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning

vanes shall be securely fastened to prevent noise or vibration. All ducts shall be fabricated and installed in accordance with modern design practice. The sheet metal gauges and fabrication procedures as given in I.S. specifications shall be adhered to and shall be considered as an integral part of these specifications.

The ductwork shall be varied in shape and position to fit actual conditions at building. All changes shall be in accordance with accepted duct design and subject to the approval of the engineer-in-charge. The Contractor shall verify all measurements at building and shall notify the Engineer-in-Charge of any difficulty in carrying out his work before fabrication.

Sponge rubber or approved equal gaskets shall be installed between all connections of sheet metal ducts to walls. Sheet metal connections shall be made to walls and floors by means of galvanized steel angles anchored to the building structure with anchor bolts and with the sheet bolted to the angles. Sheet metal connections shall be as shown in the drawings or as directed by Engineer-in-Charge.

All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angel/channel under ducts. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles / channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash / anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality thermo Cole around the duct prior to sealing of the opening.

All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 100 mm long but not more than 200 mm, securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

Flanges and supports are to be black, mild steel and are to be primer coated on all surfaces before erection and painted with aluminum thereafter. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.

The ductwork should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling Contractors.

4. SPECIFICATIONS FOR FACTORY FABRICATED DUCTING

Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards (“HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995” SMACNA)

4.1 Duct Connectors and Accessories

All transverse duct connectors (flanges / cleats) and accessories/related hardware are such as support system shall be zinc-coated (galvanized).

4.2 FABRICATION STANDARDS

4.2.1 All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be factory-fabricated. Equivalency will require fabrication by utilizing the following machines and processes to provide the requisite quality of ducts and speed of supply. Coil lines to ensure location of longitudinal seams at comes / folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct. All ducts, transformation pieces and fittings to be made on CNC profile cutlers for required accuracy of dimensions, location and dimensions of notches at the folding lines. All edges to be machine treated using lock formers, flanges and roller for fuming up edges. Sealant dispensing equipment for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified will be used.

5. SELECTION OF G.I. GAUGE AND TRANSVERSE CONNECTORS

Duct Construction shall be in compliance with 2" (500Pa) w.g. static norms as per SMACNA. All transverse connectors shall be similar to Rolamate 4-bolt slip-on flange system or equivalent of similar 4-bolt systems with built-in sealant if any to avoid any leakage additional sealant to be used. The specific class of transverse connector and duct gauge for a given duct dimensions will be 1"(250 Pa) pressure class. Non-toxic, AC -applications grade P.E. or PVC Casketing is required between all mating flanged joints. Gasket sizes should conform to flange manufacturer's specification.

6. DUCT CONSTRUCTION

6.1. The fabricated duct dimensions should be as per approved drawings and all connecting sections are dimensionally matched to avoid any gaps.

6.2 Dimensional Tolerances: All fabricated dimensions will be within ± 1.0 mm of specified dimension. To obtain required perpendicularity, permissible diagonal tolerances shall be ± 1.0 mm per meter.

6.3 Each and every duct pieces should be identified by color coded sticker which shows specific part numbers, job name, drawing number, duct sizes and gauge.

6.4 Ducts shall be straight and smooth on the inside Longitudinal seams shall be airtight and at comers only, which shall be either Pittsburgh or Snap Button Punch as per SMACNA practice, to ensure air tightness.

6.5 Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Turning vanes or air splitters shall be installed in all bends and duct collars designed to permit the air to make the tum without appreciable turbulence.

6.6 Plenums shall be shop/factory fabricated panel type and assembled at site.

6.7 FACTORY FABRICATED RECTANGULAR GSS DUCTING.

All ducts shall be fabricated from galvanized steel / aluminum of the following thickness, as indicated as below:

Rectangular Ducts G. S.	**External Pressure 500 Pa**		
	Duct Section Length 1.2 m (4 ft)		
Maximum Duct Size	**Gauge**	**Joint Type**	**Bracing Spacing**
1–600 mm	24	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	Nil

601-750 mm	24	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
751-1000 mm	22	25x25x3 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
1001-1200 mm	22	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
1201-1300 mm	20	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
1301-1500 mm	18	40x40x5 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
1501-1800 mm	18	50x50x6 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
1801-2100 mm	18	50x50x6 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
2101-2250 mm	18	50x50x6 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
2251-2400 mm	18	50x50x6 mm angle iron frame with 8 mm Dia nuts & bolts	Nil
2401-2700 mm	18	50x50x6 mm angle iron frame with 8 mm Dia nuts & bolts	600

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm
*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

NOTE:

a) DUCT USING LOCK FORMER MACHINE AT SITE SHALL NOT BE ACCEPTED.
b) MS FLANGES SHALL BE USED FOR DUCTS FOR THE AHU HAVING HEPA FILTERS.

6.7.1 Fabrication Standard: All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the machines to provide the requisite quality of ducts. Coil lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines. All edges to be machine treated.

6.7.2 Duct Construction: All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes. Ducts so identified on the Drawings shall be insulated from outside as described in the section “Insulation” and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps. Ducts shall be straight and smooth on the inside with longitudinal seams shall be airtight and at corners only which shall be either Pittsburgh or snap button as per SMACNA practice, to ensure air tightness. All ducts up to 75cms width within conditioned spaces shall have slip and drive (C & S/SS) joints. The internal ends of slip joints shall be in the direction of airflow. Care should be taken to ensure that S/SS Cleats are mounted on the longer side of the duct and Cleats on the shorter side. Ducts and accessories within ceiling spaces, visible from air-conditioned areas shall be provided with two coats of mat black finish paint. Changes in dimensions and shape of ducts shall be gradual (between 1:4 and 1:7). Air-turns (vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence. Ducts shall be fabricated as per details shown on Drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of

ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing. All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size. Plenums shall be shop/factory fabricated panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards GS sheet and riveting shall be done from outside. Self adhesive Neoprene rubber / UV resistant PVC foam lining 5mm nominal thickness instead of felt, shall be used between duct flanges and between duct supports in all ducting installation.

7. INSTALLATION

7.1 During the construction, the contractor shall temporarily close duct openings with sheet metal covers to prevent debris entering ducts and to maintain opening straight and square, as per direction of Engineer-In-Charge.

7.2 Great care shall be taken to ensure that the duct work does not extend outside and beyond height limits as noted on the drawings.

7.3 All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending or fabrication of ducts. All joints shall be air tight and shall be made in the direction of air flow.

7.4 The ducts shall be re-in forced with structured members where necessary, and must be secured in place so as to avoid vibration of the duct on its support.

7.5 All air turns of 45 degrees or more shall include curved metal blades or vanes arranged so as to permit the air to make the abrupt turns without an appreciable turbulence. Turning vanes shall be securely fastened to prevent noise or vibration. The duct work shall be varied in shape and position to fit actual conditions at building site. All changes shall be subjected to the approval of the Engineer-In-Charge. The contractor shall verify all measurements at site and shall notify the Engineer-In-Charge of any difficulty in carrying out his work before fabrication.

7.6 Sponge rubber or approved equal gaskets of 6 MM maximum thickness shall be installed between duct flanges as well as between all connections of sheet metal ducts to walls, floor columns, heater casings and filter casings. Sheet metal connections shall be made to walls and floors by means of wooden member anchored to the building structure with anchor bolts and with the sheet screwed to them.

7.7 Flanges bracings and supports are to be sourced from the duct manufacturer. Accessories such as damper blades and access panels are to be of materials of appropriate thickness and the finish similar to the adjacent ducting, as specified.

7.8 Joints, seams, sleeves, splitters, branches, takeoffs and supports are to be as per duct details as specified, or as decided by Engineer-In-Charge.

7.9 Joints requiring bolting or riveting may be fixed by Hexagon nuts and bolts, stove bolts or buck bolts, rivets or closed centre top rivets or spot welding. Self tapping screws must not be used. All jointing material must have a finish such as cadmium plating or Galvanized as appropriate.

7.10 Fire retarding flexible joints is to be fitted to the suction and delivery of all fans. The material is to be normally double heavy canvass or as directed by Engineer-In-Charge. On all circular spigots the flexible materials are to be screwed or clip band with adjustable

screws or toggle fitting. For rectangular ducts the material is to be flanged and bolted with a backing flat or bolted to mating flange with backing flat.

7.11 The flexible joints are to be not less than 75 MM and not more than 250 MM between faces. The duct work should be carried out in a manner and at such time as not to hinder or delay the work of the other agencies especially the boxing or false ceiling contractors.

Duct passing through brick or masonary, wooden frame work shall be provided within the opening. Crossing duct shall have heavy flanges, collars on each side of wooden frame to make the duct leak proof.

7.12 The work shall meet with the approval of Consultant/customer in charge in all its parts and details All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required cross sectional area being maintained) all as per the site requirement. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of consultant/customer in charge.

7.13 All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle / channel or a pair of brackets, connected by galvanized steel rod under ducts**.** The spacing between supports should be not greater than 2.0 meter. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats or fully threaded galvanized rods can be screwed into the anchor fasteners. Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Consultant / customer in charge. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor’s work in the building. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of fire retarding flexible heavy canvas sleeve at least 10cm long securely bonded and bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

8. DOCUMENTATION TO MEASUREMENTS

For each drawing, all supply of duct work must be accompanied by computer-generated detailed bill of material indicating all relevant duct sizes, dimensions and quantities. In addition, summary sheets are also to be provided showing duct areas by gauge and duct size range as applicable.

Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.

All duct pieces to have a part number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement, verification and approvals.

9. TESTING

After duct installation, a part of duct section (approximately 5% of total duct work) may be selected at random and tested for leakage. The procedure for leak testing should be followed as per SMACNA- "HVAC Air Duct Leakage Test Manual: (First Edition). All duct supports, flanges, hangers and damper boxes etc shall be given 2 coats of red oxide paint before installation and one coat of aluminum paint after the erection, at no extra cost. All angle iron flanges are to be welded electrically and holes to be drilled. All the angle iron flanges are to be connected to the GSS ducts by rivets at 100 mm centers.

After completion, all duct system shall be tested for air leakage.

The entire air distribution system shall be balanced to supply the air quantity as required in various areas and the final balance of air quantity through each outlet shall be submitted to the engineer-in-charge for approval. Measured air quantities at fan discharge and at various outlets shall be identical to or less than 5% in excess of those specified and quoted. Branch duct adjustments shall be permanently marked after air balancing is completed so that these can be restored to their correct position if disturbed at any time.

SPECIFICATIONS FOR AIR TERMINALS

1 SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of air terminals and dampers conforming to these specifications and in accordance with the requirement of drawings and 'Schedule of Quantities'.

2. TYPE

The terminals shall be of type as indicated in drawings and 'Schedule of Quantities'

3. DAMPERS

At the junction of each branch duct with main duct and split of main duct, volume control dampers must be provided. Dampers shall be rigid in construction to the passage of air.

The volume dampers shall be of an approved type, lever operated and complete with suitable level links & quadrants, locking devices, which will permit the dampers to be adjusted and locked in any position.

The dampers shall be of opposed blade or louver type. The damper blade shall not be less than 1.25 mm (18) gauge and shall not be over 225 mm wide. Automatic and manual volume opposed blade dampers shall be complete with frames and bronze bearings as per drawings. Damper frames shall be constructed of 16 gauge steel

After completion of the duct work, dampers are to be adjusted and set to deliver the required amount of air as specified in the drawings.

4 ACCESS PANEL

A hinged and gasket access panel shall be provided on duct work before each control device that may be located inside the duct work. Doors shall be provided with neoprene rubber gaskets. Angle joints shall be provided with neoprene rubber gaskets for leak tightness of the joints. Access door/panels shall be provided: -

- Near each smoke sensor
- Any other place specifically mentioned in the drawing or if asked by Owner / Consultants during execution stage.

5. SUPPLY AND RETURN AIR DIFFUSERS

Supply and return air diffusers shall be made of extruded aluminum section as specified in BOQ. The diffusers shall be powder coated in finish. Supply air diffusers shall be provided with screw operated opposed blade volume control devices of GSS in black mat finish. The diffusers shall be suitable for concealed fixing arrangement and as approved by Architect/Consultant.

The diffusers shall be provided with removable central core.

All diffusers shall be selected as per selection curves and in consultation with Architect / Consultant. All diffusers shall have soft continuous rubber/foam gasket between the periphery of the diffusers and the surface on which it has to be mounted.

6. LINEAR GRILLS:

Linear continuous supply or return air grills shall be extruded aluminum construction with fixed horizontal bars at 0 / 15 ^{0} inclination with flanges on both sides. The thickness of

fixed bar louvers shall be 3mm in front and the flange shall be 20mm wide with round edges. The grille shall be suitable for concealed fixing and horizontal bars of the grille shall be mechanically crimped from the back to hold them.
Volume control device of GSS construction in black mat finish shall be provided in S.A. duct collars.

7. ADJUSTABLE LOUVERED SUPPLY / RETURN AIR GRILLS WITH HORIZONTAL / VERTICAL OR VERTICAL / HORIZONTAL LOUVER ARRANGEMENT:

The grille shall be adjustable as each louver shall be pivoted to provide pattern with 00 to plus or minus 150 ARC upto 300 deflection down towards. The louvers shall hold deflection settings under all conditions of velocity and pressure. The rear louver of the register shall be in black shade.

Volume control device of GSS construction with black mat finish shall be provided in S.A. grills.

8. EXHAUST AIR REGISTER:

Exhaust air register shall be made of extruded aluminum with fixed horizontal louvers at 40 degree angle setting on a 20 mm louvers pitch. The register shall have 20 mm wide flange with round edges all around. The register shall be suitable for front screw fixing.

Volume control device of GSS construction with black mat finish shall be provided.

9. LINEAR CEILING MOUNTED DIFFUSERS:

Linear ceiling mounted air terminals shall be made of extruded aluminum surface mounted one way or two way pattern. The linear terminal shall have alignment strips to give straight look while installation. Volume control device of GSS construction in black matt finish shall be provided in S.A. diffuser.

10. FRESH AIR INTAKE LOUVERS:

Fresh air intake louvers 50 mm deep (minimum) wherever required as per shop drawing will be made of extruded aluminum construction duly anodized or powder coated. Bird/insect screen will be provided with the intake louvers. The blades are inclined at 45^0 on a 40 mm blade pitch to minimize water ingress. The lowest blade of the assembly shall extend out slightly to facilitate disposal of rainwater without falling in door/wall on which it is mounted.

Wherever specified, the intake louvers shall be provided with factory fitted all aluminum construction volume control dampers in black anodized finish.

11. MISCELLANEOUS

Sponge rubber gaskets also to be provided behind the flange of all grills. Each shoot from the duct, leading to a grille, shall be provided with an air deflector to divert the air into the grille through the shoot. Inspection doors measuring at least 450 mm x 450 mm are to be provided in each system at an appropriate location, as directed by Engineer-in-Charge.

Diverting vanes must be provided at the bends exceeding 600 mm and at branches connected into the main duct without a neck. Proper hangers and supports should be provided to hold the duct rigidly, to keep them straight and to avoid vibrations. Additional supports are to be provided where required for rigidity or as directed by Engineer-in-Charge. All duct work joints are to be true right angle and with all sharp edges removed.

12 **PAINTING**

All grilles, and diffusers shall be powder coated in color as approved by Architect / Consultant before installation.

All ducts immediately behind the grilles / diffusers etc are to be given two coats of black paint in Matt finish. The return air and dummy portion of all linear grilles shall be provided with a vision barrier made of 24 gauge galvanised sheets. The vision barrier shall be fixed to the false ceiling frame with self tapping screws and shall be given two coats of black paint in matt finish. Care shall be taken to ensure that the return air path is not obstructed.

SPECIFICATIONS FOR INSULATION

1 SCOPE

The scope of this section comprises the supply, installation, testing and commissioning of air terminals and dampers conforming to these specifications and in accordance with the requirement of drawings and 'Schedule of Quantities'.

2 MATERIAL

Insulation material for **Duct insulation** shall be Closed Cell Elastomeric Nitrile Rubber. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.038 W/m^{o}K or 0.313 Kcal/M hr^{o}C or 0.212 BTU/(Hr-ft^{2}-°F/inch) at an average temperature of 30°C. The product shall have temperature range of –40°C to 105°C. Density of material shall not be less than 0.06 gm/cm^{3}. The insulation shall have fire performance such that it passes minimum CLASS O as per BS476 part 7 for surface spread of flame. Water vapour permeability shall not exceed 0.024 per inch (3 x 10 $^{-14}$ Kgs/m.sec.Pa). The material shall have approval from the Chief Fire Officer.

Insulation material for **Duct Acoustic Lining** shall be resin bonded fibre glass. The thermal conductivity shall not exceed 0.034K Cal/(hr-sq.m-deg C/meter) or 0.23 BTU/ (hr.sq.ft.-deg F)/inch) at 32 deg C (90 deg F) mean temperature and density shall be not less than 32 Kg/Cum. Thickness of the insulation shall be as specified for the individual application. Each lot of insulation material delivered at site shall be accompanied with manufacturer test certificate for thermal conductivity values and density. Samples of insulation material from each lot delivered at site may be selected by Engineer in charge and gotten tested for thermal conductivity and density at Contractor's cost All joints shall be sealed properly with adhesive, which shall provide similar vapour barrier as the original insulating material.

3 APPLICATION

3.1 Duct acoustic Lining: Thickness of the material shall be as specified for the individual application. Ducts so identified and marked on drawings and included in Schedule of Quantities shall be provided with acoustic lining of thermal insulation material for a distance of minimum 5 meters as follows:

The inside surface for the ducts shall be cleaned, and provided with 22 gauge GI Channels 25 x 25 mm screwed back to back and fixed on the inside of duct, spaced not more than 60 cm center to form a frame work of 60 x 60 cms square. Cut panels 60 x 60 cms of fiber 25 mm thick shall be fitted in the squares. The insulation panels shall be fired to the sheet metal with cold setting adhesive compound and covered with fibre glass tissue paper.

The inner most surfaces shall be covered with 28 gage perforated aluminium sheet having atleast 15 percent perforations. The aluminium sheet shall be screwed to GI channels using cup washer and neatly finished to give true inside surface.

3.2 Duct Insulation: External thermal insulation shall be provided as follows: The thickness of closed cell shall be as shown on drawing or identified in the schedule of quantity. Following procedure shall be adhered to:

- Duct surfaces shall be cleaned to remove all grease, oil, dirt, etc. prior to carrying out insulation work. Measurement of surface dimensions shall be taken properly to cut closed cell elastomeric rubber sheets to size with sufficient allowance in dimension.
- Material shall be fitted under compression and no stretching of material shall be permitted.
- A thin film of adhesive shall be applied on the back of the insulating material sheet and then on to the metal surface. When adhesive is tack dry, insulating material sheet shall be placed in position and pressed firmly to achieve a good bond.
- All longitudinal and transverse joints shall be sealed with adhesive SR 998 or equivalent.
- 26 G GI Chicken wire mesh shall than be wrapped on the insulated duct to hold the insulation.

3.3. FIRE BREAKS INSULATION

Firebreaks shall be provided in all ducts for internal lining/external thermal insulation after a run of 10 m center to center. There shall be a discontinuity of the insulating material in the form of MS angle of a minimum of 50 mm x 50 mm x 3 mm size. At the interface of the MS angle and insulating material, proper care of tucking in of the insulating material shall be taken so as to prevent erosion.

SPECIFICATIONS FOR VARIABLE FREQUENCY DRIVES

1 GENERAL

The VFD shall not be a general purpose product, but a dedicated HVAC engineered design. The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch. The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. VFD shall be manufactured in ISO 9000, 2000 certified facilities. The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive. The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating. The VFD shall be supported locally by the manufacturer who will provide full technical support, spares holding and trouble shooting capability from their own local facility. The VFD should have IP 55 enclosure with integral Mains Disconnect Switch, with no additional cabinets shall be capable of operating at full speed, full load operation with continuous drive rated output current between -10 to 45°C for ratings upto 90 kW without derating and 0 to 95% RH without condensing. VFD should be able to bear AC line voltage variation of $\pm$ 10% of nominal with full output. No side clearance shall be required for cooling. All power and control wiring shall be done from the bottom.

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

The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating. The VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted / coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load. The VFD shall have a dual 5% impedance DC link reactor (harmonic filters) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical. IEEE519, 1992 recommendations shall be used for the basis of calculation of total harmonic distortion (THD) at the point of common coupling (PCC). On request VFD manufacturer shall provide THD figures for the total connected load. The contractor shall provide details of supply transformer rating, impedance, short circuit current, short circuit impedance etc to allow this calculation to be made. All VFDs shall contain integral EMC Filters to attenuate Radio Frequency Interference conducted to the AC power line. The VFDs shall comply with the emission and immunity requirements of IEC 61800-3:2004, Category C1 with 50m motor cable (unrestricted distribution). The suppliers of VFDs shall include additional external EMC filters, if required, to meet compliance to this requirement.

The VFD’s full load output current rating shall meet or exceed the normal rated currents of standard IEC induction motors. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting. The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was

used at reduced speeds. Breakaway current of 160% shall be available. A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings. The VFD must be able to produce full torque at low speed to operate direct driven fans. Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. An Automatic Motor Adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test. Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency or only manually adjustable carrier frequency are not acceptable. The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the VFD and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations. VFDs not meeting this requirement of 100 meters of cable length between motor & cable because of generation of high U peak Voltage and high dv / dt on the motor terminals, which may cause motor windings to fail or significantly curtail it's life, shall be compensated with the use of external suitable dv/dt or sine wave filters.

2 PROTECTIVE FEATURES

A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature shall be available. The VFD shall display all faults in plain English text and not in codes. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage. VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost. If the temperature of the VFD's heat sink rises to 80℃, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high. In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping. The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running. The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode. The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.

3 INTERFACE FEATURES

Hand off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation. There shall be an “Info” key on the keypad. The Info key shall include “on-line” context sensitive assistance for programming and troubleshooting. The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System. Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD’s keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status. Display shall be programmable to communicate in multiple languages including English.

FAULT light, WARNING light and POWER-ON light shall be provided which shall be visible both on the keypad and on the VFD when the keypad is removed. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications. A three-feedback PID controller to control the speed of the VFD shall be standard. This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals. The VFD shall be able to apply individual scaling to each feedback signal. For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow. The VFD’s PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system. The VFD shall have three additional PID controllers which can be used to control damper and valve positions in the system and to provide set point reset. Floating point control interface shall be provided to increase/decrease speed in response to contact closures. Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others. Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set “sleep” level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD’s speed is being controlled by its PID controller, it shall be possible to program a “wake-up” feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD. A run permissive circuit shall be provided to accept a “system ready” signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output “run request” signal to indicate to the external equipment that the VFD has received a request to run. VFD shall be programmable to display feedback signals in appropriate units. VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry. Two terminals shall be programmable to act as either as digital outputs or additional digital inputs. Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status. Each relay shall have an adjustable on delay / off delay time. Two programmable analog inputs shall be provided that can be either direct-or-reverse acting. Each shall be independently selectable to be used with either an analog voltage or current signal. The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA. A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise. The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting. One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output. It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications. It shall be possible to command all digital and analog output through the serial communication bus. It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs. These modules shall use rigid connectors to plug into the VFD's control card. The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module. Modules may include such items as:

- Additional digital outputs, including relay outputs
- Additional digital inputs
- Additional analog outputs
- Additional analog inputs, including Ni or Pt temperature sensor inputs

It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD. Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display FIREMODE whenever in firefighter's override mode. Firemode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions. A real-time clock shall be an integral part of the VFD. It shall be possible to use this to display the current date and time on the VFD's display. Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter set points and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours. The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log. The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time. The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

- Comparators for comparing VFD analog values to programmed trigger values
- Logic operators to combine up to three logic expressions using Boolean algebra
- Delay timers
- A 20-step programmable structure

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

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

- Metasys N2
- Modbus RTU

VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system. The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading. Minimum 4 independent setups shall be provided with 4 preset speeds per setup shall be provided for a total of 16 setups. Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds. Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds. An automatic "start delay" may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired. Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

SPECIFICATIONS FOR ELECTRICAL WORK AND CABLING

1. **General :**

The motor and switchgears required for various items shall generally be as per specifications given below all electric motors shall be suitable for 3 phase, 50 cycles, 415 volts A.C. Supply +/- 10%.

2. **Switch Panel Board :**

- The main L.T. Panel board shall be extendible type on both sides, having in it all switches, starters and accessories and completely factory prewired. It shall be suitable for voltage systems upto 500 volts, 3 phase, 50 Hz, 4 wire supply capable of functioning satisfactorily in temperatures of $47^{o}C$ and rupturing capacity not below 35 MVA.

- The boards shall be fabricated from 2.0 mm thick, cold rolled M.S. sheets. The front opening door panels shall be from 2 mm thick, cold rolled M.S. Sheets. Suitable stiffeners shall be used in fabricating the housing. A clear space of 450 mm shall be left at the bottom. All steel members shall first be degreased and then de-scaled using dilute sulphuric acid and a suitable phosphating process (7 Tank Process) then the boards shall be given 2 coats of red oxide primer and finished with stove enamel finish. The switch board shall be dust proof and vermin proof. The panel shall generally confirm to is 8623 (fully conformity not called for). It shall be flush in front and back. The panel shall have front and rear access.

- Cable compartment of adequate size shall be provided in the main distribution board for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate support shall be provided in cable compartment to support cables. All incoming and outgoing switch terminals shall be brought out to terminal blocks in cable compartments.

- All switches below upto 32 Amps shall be MPCB of required rating and all switches 63 Amps and above shall be MCCB of adequate 50 KA fault rating.

- No MCCB/MCB, starter or accessories shall be provided in the bottom 450 mm of the panel.

- The bus bars shall be of aluminium strips of minimum specified ratings with PVC heat shrinkable sleeves of appropriate colour. There shall be adequate clearance between phase to phase and phase to neutral strips.

- Items such as ammeters, switches etc shall be located close to the corresponding switchgear, and otherwise all items shall be arranged in a neat symmetrical pattern.

- Every starter / contactor etc. shall be controlled by a MPCB / Moulded Case Circuit Breaker of adequate rating.

- A voltmeter and ammeter shall be provided to indicate incoming voltage alongwith a rotary phase selection switch.

- Ammeters shall be provided for all motors of 7.5 HP and higher ratings. An ammeter to measure total current consumption should also be provided in such cases. Each switch, ammeter etc. Shall be provided with a name plate to indicate controlled items. All ammeters and voltmeters where specified shall be of 144 x 144 mm size.

- Panel fabrication drawings shall be got approved before fabrication.

- LED type indicating lamps in approved colours shall be provided for the 3 phases and for on status of all controlled devices.

- All the switches/breakers shall be interlocked with door so that the unit cannot be closed unless the unit door is closed. The interlock shall also prevent opening the unit door unless the switch/breaker is in off position.

- Default arrangement shall be provided for deliberate inspection of switch/breaker without having to switch off the unit.

- All the units pertaining to a motor shall be incorporated in one cabin i.e. switch, starter, etc ammeter single phasing preventor, indicating lamps, etc.

- All the switch gear shall be earthed to the earth bus. Earth shall be extended to each compartment to the door by means if a flexible, insulated copper conductor with crimped legs on either side.

- Etched plastic name plates shall be provided for all the incoming, outgoing switch gears etc.

- The doors of the switch compartments and cable access shall be hinged type and that of busbars shall be fixed type. The knobs of the hinged doors shall be provided with a locking arrangement to prevent them from falling down when they are unscrewed for opening the doors. All panel doors shall have rubber gasket of suitable type to make the compartment dust proof.

- All the control and auxiliary wiring shall be carried out with PVC insulated copper conductor of proper colour code and minimum 2.5 sq mm copper flexible wire shall be used.

- Ammeters for incoming current shall be operated with CTs and a selector switch.

- Each panel shall be provided with suitable size of earth bus at the rear of the panel and two earth terminals on either side.

- Suitable printed PVC ferrules shall be provided for all the conductors for easy identification.

- The power wiring from the switches/unit breakers to the starters shall be carried out using colour coded, PVC insulated copper conductors crimped with lugs.

- The out going of starter shall also be PVC insulated colour coded copper conductor crimped with lugs and terminated on a terminal block of proper rating.

- A danger notice plate of 200 mm x 150 mm of mild steel at least 2 mm thick vitreous enameled white on both sides and with inscriptions in signal red colour on front side shall be provided on the panel board.

3. **Wiring for Motors, Heaters etc :**

- The wiring for above equipment shall be carried out in conduits or using PVC armoured cables.

- The PVC XLPE armored power cable for use on 415 volts system shall be 3 or 3.5 core with aluminium conductors and be of 1100 volts grade, as per IS 1554 part I-1964. The cross section of the cable shall be to suit the load or rating of the equipment. The cable shall be

aluminium conductor XLPE insulated single wire / strip armored with overall PVC sheathing.

- The cables shall be laid as per IS-1255/1967, Indian Standard Code of Practice.

- The cables shall be laid, as per drawings or along a short and convenient route between switch board and the equipment, either in trenches, on wall or on hangers, supported from the slab. Cable routing shall be checked on the site to avoid interference with structure, equipment etc. Where more than one cable is running close to each other, proper spacing should be provided between them.

- The radius of bends of the cable should not be less than 12 times the radius of cable to prevent undue stress and damage at the bends, the cables should be supported with wooden cleats fixed on M.S. Supports, when running in trenches wall or ceiling suspended hangers. When laid underground the cables should be covered with fine soft earth and protected with cement concrete covering. Suitable G.I. Pipe shall be used wherever the cable comes out of the connected surface and clamped properly.

- Wooden bushes shall be provided at the ends of pipes through which cables are taken in walls and floors.

- All cables shall be terminated using suitable size cable glands and packing.

- The wiring in conduits shall be 1100 volts grade.

- The conduits used shall be of high quality, all joints shall be made with sockets. The bends and elbows shall have inspection covers fixed with grease free screws. The joints shall be water tight. Approved metal saddles shall be used to secure the exposed conduits at a space of 1 meter or less. The connection of the conduit to switches etc. shall be secured by a check nut and ebonite bushes provided at the ends of conduits.

- Flush inspection covers shall be provided in case of concealed, recessed conduits. The staples for the conduits shall not be spaced more than 0.60 meters apart. Before filling up the chase with concrete the conduits should be given a coat of rust proof paint.

- The wires shall be drawn only after all the conduits have been properly fixed in position.

4. **Control Wiring :**

- Control cables shall be 650 volts grade as per IS 1554 made from copper conductor of 1.5 / 2.5 sq. mm PVC insulated single multi core unarmoured with an overall PVC sheathing. All cables & wires to be FRLS glade.

- The cables and conduits wiring shall be carried out as per details given above.

5. **Earthing :**

All equipment connected with electric supply shall also be provided with double earthing continuity conductors. The size of copper earthing conductors shall be:-

Size of phase wire sq.mm Aluminium	size of copper conductor tape/wire (swg)
185	20 mm x 3 mm (strip)
150	20 mm x 3 mm (strip)
120	12 mm x 3 mm (strip)
70	4 Swg

50	6 Swg
35	8 Swg
25-6	8 Swg
4	10 Swg

Note: GSS earthing conductors of equivalent size may be used in lieu of copper earth mentioned above.

6. **Miscellaneous :**

- The final connections to the equipment shall be through flexible connections in case of conduit wiring and also where the equipment is likely to be moved back and forth, such as on slide rails.

- An isolator switch shall be provided at any motor which is separated from the main switch panel by a wall or partition or other barrier or is more than 15 meters away from the main panel.

- Two separate and distinct earthing conduits shall be connected from the equipment upto the main switch board panel.

- The branch lines from the main panel to each equipment shall be separated and should not crisscross other lines.

- The entire installation shall be tested as per electricity rules and I.S.S 732-1973 with amendments 1, 2 & 3 prior to the commissioning of the plant and a suitable test report furnished by a competent and authorised person. The test report will be obtained by contractor himself at his own expenses.

- All exposed switch board panels, conduits; hangers etc. shall be given 2 coats of suitable paint of approved colour, when all work has been completed.

7 Painting: All sheet steel work shall undergo a process of degreasing, thorough cleaning, and painting with a high corrosion resistant primer. All panels shall then be baked in an oven. The finishing treatment shall be by application of powder coating of approved shade.

8 Rubber Mat: Rubber mat shall be provided in front to cover the full length of all panels. Where back space is provided for working from the rear of the panel, rubber mat shall also be provided to cover the full length of panel.

PREAMBLE TO MODE OF MEASUREMENT

1 All equipment described hereafter shall be in accordance with the specifications. All equipment shall be selected and installed for the lowest Operating noise level.

2 Supply of various equipment shall include all expenses for correspondence with manufacturers, submission of shop drawings, documents and their approval by the Consulting Engineer, procurement of equipment, transportation, shipping, payment of all taxes and levies, storage, supply of equipment at the point of installation, furnishing all technical literature required, replacement of defective components, and warranty obligations for the individual equipment.

3 Installation of various equipment shall include all material and labour associated with hoisting and lowering of equipment in position, insulation of the components and vibration isolation as required, grouting and anchoring or suspension arrangements and all incidentals associated with the installation as per the specifications and manufacturer's recommendation.

4 Vibration isolators as specified or as recommended by the manufacturer shall be installed with each component. Performance ratings, power consumption and power data for each component shall be verified at the time of testing and commissioning of the installation, against the data submitted with the tenders.

5. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirit, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop painted surfaces.

6. Testing and commissioning shall include furnishing all labour, materials, equipments, instruments, and incidentals necessary for complete testing of each component as per the specifications and manufacturer's recommendations, submission of test results to the Consulting Engineer and obtaining their approval and submission of necessary documents and completion drawings.

7 All ducts shall be fabricated and installed conforming to the relevant Indian standards, approved shop drawings and the specifications.

8. Duct installation shall include fabricating and installing the ducts, splitter dampers, turning vanes, and distribution grids within the ducts in position, and providing, installing and making air tight all joints with slips, bonded felt insertions, nuts, bolts and screws as required. In addition multi-louvered manually adjustable dampers shall be provided in various branch ducts as required or shown on drawings for proper balancing of air flows.

9 All registers and diffusers shall be provided with a soft continuous rubber gasket between their periphery and the surface on which these have to be mounted.

10 Registers and diffusers shall be given, at the factory, a rust resistant primer coat and enamel paint finish of approved colour.

11 After completion of the installation, the entire air distribution system shall be tested for air leaks and balanced in accordance with the specifications.

MODE OF MEASUREMENT

1 Measurement of Equipment:

- VRV/ VRF/ ductable unit – to include compressor, condenser, controls, motor etc on skid mounted platform complete factory assembled including chiller insulation and standard accessories as supplied by the OEM. – Unit nos.
- Indoor units and cassette type FCU – to include blower with motor, casing, Unit nos.
- Electrical Panel: Panels shall be counted as number of units. Quoted rates shall include as lumpsum for all internal wiring, earthing connections within panel box. The quoted rate of panel shall also include all accessories, switchgear, contactors, indicating meters and lights as per the Specifications and Schedule of Quantities.

2 Measurements for Ducting: All ducts fabricated and installed should be accompanied and supported by proper documentation. Bill of material / Packing list for every duct section supplied. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise. Each and every duct piece to have a tag number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement and verification. Unless otherwise specified, measurements for ducting for the project shall be on the basis of centerline measurements described herewith. Ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in a similar manner. For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centerline distance between the flanges of the duct section. For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline. The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 5mm thick between duct and support, vibration isolator suspension where specified or required. The following accessories will be part of ducting and shall NOT be separately measured nor paid for

- inspection chamber / access panel,
- splitter damper with quadrant and lever for position indication,
- turning vanes,
- straightening vanes
- all other accessories required to complete the duct installation as per the specifications.

3 Air Distribution accessories shall be measured by the cross-section area perpendicular to air flow, as identified herewith:

- Grilles and registers - width multiplied by height, excluding flanges.
- Volume control dampers - width multiplied by height, excluding flanges
- Diffusers - cross section area for air flow at discharge area, excluding flanges.
- Fire dampers - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary collars and flanges for mounting, inspection pieces with access door, electrical actuators and panel. No special allowance shall be payable for extension of cross section outside the air stream.

- Flexible connection - shall be measured by their cross sectional area perpendicular to the direction of air flow. Quoted rates shall include the necessary mounting arrangement, flanges, nuts and bolts and treated-for-fire requisite length of canvas cloth.
- Motorised Volume control damper - width multiplied by height, excluding flanges.
- Exhaust air / Fresh air Louvers - shall be measured by their cross sectional area perpendicular to the direction of air flow.

4 Measurement of Duct Insulation: Unless otherwise specified measurement for duct insulation for the project shall be on the basis of centre line measurements described herewith Duct Insulation shall be measured on the basis of surface area along the centre line of insulation thickness. Thus the surface area of externally thermally insulated or acoustically lined be based on the perimeter comprising centre line (of thickness of insulation)width and depth of the cross section of insulated or lined duct, multiplied by the centre-line length including tapered pieces, bends, tees, branches, etc. as measured for bare ducting.

5 Measurement For Piping: Unless specified otherwise, measurement for piping for the project shall be on the basis of centre line measurements described herewith Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted. The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, MS channel, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately measured nor paid for. However, all valves (gate / globe / check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications. Piping measurements shall be taken before application of the insulation. Contractor shall get pressure testing of pipes / measurements etc verified by the representative of Engineer in charge at site.

6 Measurement of Pipe Insulation: Pipe Insulation shall be measured in units of length along the centre line of the installed pipe, strictly on the same basis as the piping measurements described earlier. The linear measurements shall be taken before the application of the insulation. It may be noted that for piping measurement, all valves, orifice plates and strainers are separately measurable by their number and size. It is to be clearly understood that for the insulation measurements, all these accessories including cladding, valves, orifice plates and strainers shall be considered strictly by linear measurements along the centre line of pipes and no special rate shall be applicable for insulation of any accessories, fixtures or fittings whatsoever.

7 Measurement of cabling: All power cabling, control cabling and earthing the same shall be measured for actual length and paid as per the unit rates available in the tender quotes.

INSPECTION AND TESTING PROCEDURES

All major equipments such as packaged units, panels, fans shall be got inspected by the engineer in charge / customer at works by the AC contractor, if he so desires. All routine and Type tests shall be carried out and the test reports shall be submitted for approval before dispatch. The engineer in charge is free to witness any or all tests. In any case the OEM test certificates shall be submitted to the engineer in charge for verification of the same before the payments for the same can be processed. The AC contractor shall inform the engineer in charge well in time about the date of readiness of the equipment for inspection and testing. The inspection process shall be as under:

Equipment like packaged units, Ductable units, fans, Indoor units

- Salient features such as model and make shall be checked as per the contract requirement and shall be related with name plate/performance curves.
- The manufacturer's test certificate shall be furnished and verified.
- The test certificates shall be correlated with the equipment serial no.

Electric Motor

- The motor shall be of approved make. The OEM's test certificates shall be furnished and verified with the name plate and serial no. The requirement shall be as per technical dat submitted.

Pipes

- Make, wall thickness for the pipe shall be checked at random for 5% of pipe lengths and shall be correlated with relevant IS codes.

Ducting

- The GI sheet to be used shall be physically checked for gauge as per IS 277. The bend test shall be performed at site. Randomly one sample of each gauge shall be checked chemically for composition and galvanizing by a reputed lab and report shall be submitted before starting work at site.

Insulation

- All type of insulation material shall be physically checked for quality, thickness as per tender specification.
- The samples shall be checked for density at site. The same shall be correlated with the OEM test certificates.
- The material shall be having required thermal conductivity which will be verified from TC.

Final Inspection

After completion of entire installation as per specifications in all respects, the AC contractor shall demonstrate trouble free operation of the entire installation simultaneously. The test readings shall be recorded in a mutually acceptable format. All tests shall be carried out by the AC contractor at his own expenses. However necessary utilities such as power and water shall be provided by the owner free of cost. The tests shall include but will not be limited to the following:

- To check satisfactory functioning of all equipment installed
- Clean all equipment to remove foreign material and construction dirt and dust with Vacuum cleaner.
- Verify that the equipment is secure on mounting and supporting devices and that connections for piping, ductwork and electrical are complete.
- Verify proper thermal overload protection is installed in motors, starters, and disconnects.
- Perform cleaning and adjusting specified as per OEM.

- Check proper motor rotation direction and verify fan wheel / pump free rotation and smooth bearing operations.
- Reconnect drive system and align belts.
- Lubricate bearings, pulleys, belts, and other moving parts with factory recommended lubricants.
- Set outside-air / supply air dampers to minimum outside-air setting.
- Install temporary throw away filters for initial run and finally install clean filters.
- Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.
- Replace fan and motor pulleys as required to achieve design conditions.
- Measure and record motor electrical values for voltage and amperage.
- Shut unit down and reconnect automatic temperature control operators.
- Cooling / heating capacity of various Indoor units shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by a calibrated rotating vane anemometer and temperature measurements by accurately calibrated mercury-in-glass thermometers. Computed ratings shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current, whereas, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

NOTE:

- All measuring instruments such as thermometer, Psychrometer, Pressure gauges, anemometers, Flowmeter, dB Meter, Tong tester, etc or any other necessary instrument shall be arranged by the AC contractor at his own expense.
- The instruments shall be new and shall have a valid calibration certificate from a renowned test lab.
- The plant shall be run initially and all equipments shall be adjusted to give desired results as per contract. Thereafter the plant shall be test run for 96 hours as described above and the readings shall be demonstrated in the required format. The test shall be witnessed by the owners and engineer in charges representative. In case the conditions are not achieved during the initial run test the plant shall be readjusted and the new dates for tests shall be determined. The entire test shall be repeated and satisfactory results shall have to be obtained. Only after satisfactory test the installation shall be taken over by the customer and warranty period for one year shall commence.
- The test readings shall be suitably adjusted for the absence of Peak ambient conditions, fouling factor, and available load.
- The snag list prepared jointly after initial test shall be attended to by the vendor during a maximum of 30 days from the start of warranty period. Failure to do so shall result in corresponding increase of warranty period.

APPROVED MAKES OF EQUIPMENT & MATERIALS

S No	Equipment / Material	Approved Makes
1	Air Cooled condensing units	Blue Star / Voltas / Carrier.
2	Air handling Units	VTS / Edgetech / Zeco / Waves
3	Grilles/ Diffusers	Caryaire / Ravistar / Airflow / coolwings
4	G.I. Sheet Metal Duct	SAIL/ Tata

5	Factory fabricated duct	Zeco / Ecoduct / Rolastar
6	Duct flange	Zeco / Ecoduct / Rolastar
7	Hessian (Fire treated)	Navair/ Pyroguard
8	VCD / Gravity louvers / Exhaust& fresh air louvers	Caryaire / Ravistar / airflow / coolwings
9	PPRC Pipe	Reliance.
10	Copper Pipe	Totaline / Rajco/ Mandev
11	Humidistat	Honeywell / Siemens / Anergy
12	Safety Thermostat for heater	Anergy Controls
13	Closed cell Nitrile rubber	Armacell / K flex / vido flex
14	Aluminium Tape	Johnson/ Birla 3M
15	Fibre glass	UP twiga / Owen corning
16	Anchor fastners	Hilti /fishner
17	Paints	ICI/ Asian/ Narolac/ Berger
18	Motor Control Centre	UPS / International switchgear / IPC
19	Starter, Contactor, Push Button	Larsen & Toubro / GE Power Controls / Siemens
20	Moulded Case Circuit Breaker (MCCB) / Miniature Circuit Breaker (MCB) / Overload	Schneider Electric (MG) / Larsen & Toubro / Siemens
21	Current Transformer (Epoxy Cast Resin)	Automatic Electric / Indcoil / Pragati
22	Protection Relay (numeric type)	Alstom /Asea Brown Boveri / Siemens
23	Switch Fuse Unit, HRC Fuse /TDR /Rotary switch	Larsen & Toubro / GE Power Controls / Siemens
24	Timer	Schneider Electric (Telemechanique) / Larsen & Toubro / GE Power Control / Siemens
25	Selector Switch, Toggle switch	Larsen & Toubro / Kaycee
26	Change Over Switch	Larsen & Toubro / siemens
27	Ammeter and Voltmeter	Rishabh (L& T) / Automatic Electric
28	Indicating Lamps LED type , Push Button	Larsen & Toubro / GE Power Controls / Siemens / Vaishno Electricals

29	Variable Frequency Drives	Danfoss
30	Fine Filters / HEPA filters	Thermodyne / Spectrum / AAF

Note: For any other item required for successful completion, but not included in the above list the Contractor shall take prior written approval from the Consultant/ Owner.

PREAMBLE TO SCHEDULE OF QUANTITIES

1 All items of work under this Contract shall be executed strictly to fulfill the requirement laid down under" Basis of Design" in the specifications. Type of equipment, material, specification, methods of installation and testing and type of control shall be In accordance with the specification, approved shop drawing and relevant Indian Standards, however capacity of each component and their quantities shall as fulfill the above mentioned requirement.

2 The unit rate for all equipment's or materials cost in RUPEES for equipment and material including all taxes and duties and also including forwarding, freight, insurance and transport into Contractor's store at site storage' installation 'testing balancing ' commissioning and other work required.

3 The rate for each item of work included in the Schedule of Quantities shall' unless expressly stated otherwise, include cost of:

- All materials. Fixing materials. Accessories, appliances tools, plants, equipment transport, labour and incidentals required in preparation for and in the full and entire execution as per Specification and Drawings.
- Wastage on materials and labour.
- Loading, transporting, unloading, handling/double, hoisting to all levels. Setting, fitting, and fixing in position, protecting, disposal of debris and other labour necessary in and for the full and entire execution and for the job in accordance with the contract documents, good practice and recognize principals.
- Liabilities, obligations, and risks arising out of Conditions of Contract.

4 All requirements of Specification, whether such requirements are mentioned in the item or not. The Specification and Drawing where available, are to be read as complimentary to and part of the Schedule of Quantities and any work called for in one shall be taken as required for all.

5 In the event of conflict between Schedule of Quantities and other documents including the Specification, the most stringent shall apply. The interpretation of the Engineer in charge shall be final and binding.

6 All equipment, quantities, and technical data indicated in this Schedule are for Contractor's guidance only; these are based on the documents prepared by the Consultant. This schedule must be read in conjunction with other documents. The Contractor shall be paid for the actual quantity of work executed by him in accordance with the approved Shop Drawing at the contract rates.

7 This Schedule shall be fully priced and the extensions and totals duly checked. The rates for all items shall be filled in INK including NIL items.

8 No alteration whatsoever is to be made to the text or quantities of this schedule unless Consultant authorizes such alteration in writing. Any such alterations, cuts or additions shall unless authorized in writing, be disregarded when tender documents are considered.

9 In the event of an error occurring in the amount of the Schedule, as a result of wrong extension of the unit rate and quantity, the unit rate quoted by the tenderer shall be regarded as firm and the extensions shall be amended on the basis of rates.

10 Any error totaling the amount column and in carrying forward total shall be corrected, any error, in description or in quantity, omission of items from this Schedule shall not vitiate this corrected but shall corrected and deemed to be variation required by the engineer in charge.

11 The Contractor shall procure and bring Materials/ Equipment to the site only on the basis of drawing approved for construction and shop drawings and not on the Contractor's requisition for Engineer in charge supplied materials.

SCHEDULE OF QUANTITIES
ESTIMATE FOR STEM CELL LAB AT IISERR MOHALI

Item	Description	Unit	Qty	Rate	Amount
A	**EQUIPMENT**				

1	Supplying, installing, testing and commissioning of **Condensing UNITS** each complete with scroll compressor, motor, air cooled condenser, vibration isolators, integral refrigerant piping and wiring, accessories as required, automatic and safety controls mounted in central console panel and all mounted on a steel frame complete as per specifications. Motor shall be suitable for 415±10% 50 cycles. 3 phase AC supply. Refrigerant used shall be R-22 as detailed in specifications.		
1.1	Capacity 5.5 TR	No	3
1.2	Capacity 11 TR	No	1
2	Supply, Installation, testing and commissioning of double skin construction draw thru type AIR HANDLING UNITS each complete with pre filter section, cooling coil of copper tube & aluminium fins construction for Refrigerant, squirrel cage induction motor, backward curved centrifugal fan, belt drive and vibration isolators. Coil size shall be selected for a maximum face velocity of 500 feet / minute. Motor shall be suitable for 415±10% volts, 50 cycles, 3 phase AC supply. The AHU shall have mixing box, Cooling coil, backward curved blower, Filters along with fresh air, Return air and supply air dampers.		

	Tag No.	CFM	TR	Rows	Static		
2.1	AH 1	3000	5.5	4	140	No	1
	Sections Mixing box with pre filters (EU 3), 4 row DX cooling coil with distributor and controls, face and Bypass damper, Backward curved blower, Fine filter (EU 6), Filter (EU 9) (The AHU shall be in 2 tier construction.) (For stem Cell)						
2.2	AH 2	3500	5.5	4	110	No	2
	Sections Mixing box with pre filters (EU 3), 4 row DX cooling coil with distributor and controls, Face and bypass damper Backward curved blower, Fine filter (EU 7), HEPA Filter (EU11) (The AHU shall be in 2 tier construction.(for Virus lab, Tissue culture and FACS, Confocal)						
2.3	AH 3	5000	11	4	50	No	1
	Sections Pre filters (EU 4), 4 row DX cooling coil with distributor and controls, Forward curved blower (The AHU shall be Ceiling suspended)(for balance area)						

3	Supply, Installation, Testing and commissioning of Insulated Hard Copper Refrigerant piping as per specifications from AHU to condensing units along with Controls, Dryer, Expansion valve etc. on perforated cable trays with necessary supports as reqd. of sizes:		
3.1	34.9 mm O.D.(insulation : 19 mm)	RM	20
3.2	28.6 mm O.D.(insulation : 13 mm)	RM	30
3.3	22.6 mm O.D.(insulation : 13 mm)	RM	30
3.4	15.9 mm O.D.(insulation : 13 mm)	RM	30

4	Supply installation testing and commissioning of HEPA Filters of	Nos	
4.1	size 915 x 600 x 150 mm with HEPA filer box (bottom loading)	Nos	4
4.2	size 610 x 610 x 150 mm with HEPA filer box (bottom loading)	Nos	14
5	Supply Installation Testing and commissioning of pan type Humidifier with controls, immersion type heaters, controls and humidistat		
	6 KW	Nos	3
6	Winter Heating / Reheat package comprising of strip heater, MS frame duly painted, Humidistat, Thermostat, Internal wiring within the bank and complete as per instructions of engineer in charge of following capacity. 9 KW each.	Nos	3
7	Providing and fixing of Return Riser		
A	Factory fabricated Return air riser with internal coving and properly formed of size 750 mm x 300 mm and 2600 mm high. The riser shall be insulated from outside with 6 mm nitrile rubber on embedded sides before installation at site.	Nos	22
B	Front Cover Plate for Return Riser in 16 G CRCA construction having Hot Dip GI on back side and paintable primer on front side without paint, with champherd on both sides and inbuilt coving at top including frame for return grill fixing.		
7.1	750 x 2600 mm	Nos	22
7.2	Sq. Mtr. Rate of cover plate (for variation in area)	SM	r/o
C	Return riser cover plate mounted Grill Filter assembly with Aluminum Powder Coated Perforated Grill and 20 micron filter		
7.3	Grill - 900 x 600, Filter - 830 x 550	Nos	22
D	Volume control dampers of 16G GI frame & 24G GI aerofoil blades for RA risers.		
7.4	750 x 300 mm	Nos	22
	TOTAL CARRIED TO SUMMARY		
B	**LOW SIDE**		
1	Supply, Fabrication, installation and testing of sheet metal ducts in accordance with the approved shop drawings and as required by the specifications. (factory fabricated). **All Ducting will have MS flange and should be sealed with Silicon sealant.**		
1.1	24 gauge	Sqm.	400
1.2	22 gauge	Sqm.	270

2	Supply, fabrication, installation and testing the **flexible connections** constructed of fire resistance flexible double canvas sleeve as per the approved shop drawings.	Sqm.	1
3	Supply, installation and testing of GI construction **Louver dampers** within ducts to be provided with suitable ducts lever and quadrants for manual control of volume of air flow and for proper balancing of the air distribution system.	Sqm.	2.5
4	Supply, installation, testing and commissioning of motorized combined **smoke & fire damper** complete with motorized actuators with spring return mechanism, inter connecting wiring at locations shown in approved shop drawings and as per specifications.	Sqm.	2
5	Supply, installation, testing and balancing of Powder coated extruded aluminium construction square shape **Supply air diffusers** with removable core, anti smudge ring & with volume control damper as per specifications.	Sqm	1
6	Supply, installation, testing and balancing of Powder coated extruded aluminium construction square shape **return air diffusers** with removable core, anti smudge ring & without volume control damper as per specifications.	SQM	1
7	Supplying & fixing of opposed blade **aluminium construction perforated grilles at HEPA filter outlets** as per approved drawings and specifications.	Sqm.	7
8	Supply and installation of **External Thermal** insulation on ducts with **aluminium faced cross linked nitrile rubber** as per the approved specifications. Quoted price shall be inclusive of adhesive, tapes as per specification. 9 mm thick insulation for air ducts.	Sqm	700

9	**MAIN HVAC Panel: MCC-1** Designing, fabricating, transporting to site, Installation, testing and commissioning of floor mounted, self supported, compartmentalized LT cubical pattern (Extendable Type) metal clad switch board, fabricated from 2mm (14 G) thick CRCA sheet steel suitable for 31 MVA rupturing capacity at 415 V, 3 phase, 4 wire, 50 HZ AC supply and equipped with PVC sleeved aluminum bus bars of specified rating and following switch gears inter connected by PVC sleeved solid conductors, including 7-tank cleaning, degreasing, phosphating process and treatment of panel with anti-corrosive zinc based primer paint and finally powder coating the panel, complete with earthing terminals, cable and bus bar alleys and hoisting hooks as required. The LT panel will comprise ACBs and MCCBs as described below for incoming and outgoing power supplies. Brand\model shall be approved by the engineer incharge. Necessary cable alley, spare switches, internal wiring, control wiring / cabling and earthing of all equipment shall also be included. All starters shall have the following accessories: TPN MPCB as per the suitable rating, terminal block for power distribution, contactor, overload relay with built in single phasing protection, phase indication lights and indicating light for ON/OFF status, ammeter with CTs & selector switches, relay, auto manual selection & push buttons with SP MCB. All internal wiring and GI earthing of air handling unit motors from the panel shall be included. The panel shall include the following accessories. TPN MPCB / MCB for incoming power as per rating given below Terminal block for power distribution. Single phase preventer. Phase indicating lights and indicating light for 'ON' status with toggle switches and back-up fuses. 96 mm x 96mm voltmeter with fuse of suitable range. Ammeter of suitable range with CTs and selector switch. Time delay relay for delayed automatic restart of air handling unit motor. 220/24 volts transformer. Wiring for micro-switch smoke sensor and electric actuator for stopping the fan when smoke/fire damper closes (For AHUs provided with fire damper). Control wiring for thermostat. Bimetallic lugs shall be used at copper to aluminium joints.	Each	1

Auto / Manual start / stop selector switch shall be provided for each equipment in the panel to facilitate remote operation from Central Indication Light Panel. Panels shall have adequate space for mounting transformers and other accessories related to control system.

INCOMERS

1 No MCCB as per following details/ specification:

160A, 35kA, TPN, MCCB with in-built protection such as thermal over load, earth fault, short circuit, auxiliary contacts with door interlock facility & padlock facility shall contain the following:

(i) Voltmeter of 0-500A with VSS & one set of (RYB) phase indicating lights with 6A SP MCB

(ii) Indicating lamps protected by 6A MCB to indicate ON,OFF, TRIP for MCCB

(iii) 0 - 200 Amps 96 x 96 sqmm Ammeter with 200/5 Amps resin cast CT's and selector switch.

BUSBARS :

300 A , 35 KA, TPN Aluminium busbar duly sleeved - 1 set

Maximum density of aluminimun bus bars for current carrying capacity shall be one amp per square mm.

OUTGOINGS :

Compressor Unit - 1 Nos MCCB's as per following details/ specifications:

63A, 35KA, TPN MCCB, motor duty, with extended handle and outgoing feeder to 11 TR starter panel of compressor motor. The compartment shall contain :

(i) "ON/OFF" LED indicating lamp with 6A control SP MCB

(ii) 0 - 60amps 96 x 96 sq mm ammeter with 60/5 amps CT's and selector switch.

Compressor Unit - 4 Nos (3+1) MCCB's as per following details/ specifications:

40A, 35KA, TPN MCCB, motor duty, with extended handle and outgoing feeder to 5.5 TR starter panel of compressor motor. The compartment shall contain :

(i) "ON/OFF" LED indicating lamp with 6A control SP MCB

(ii) 0 - 50amps 96 x 96 sq mm ammeter with 50/5 amps CT's and selector switch.

Heaters- 4 Nos.(3+1) MCCB as per following details/ specification:

40 Amps, MCB,D curve with power contactor for 9KW Heaters.

(i) "ON/OFF" LED indicating lamp with 6A control SP MCB

AHU Motors # 3 Nos. 11-16 amps TPN MPCBs, 35 KA, with extended handle with power contactor for 5 HP DOL starters for outgoing feeders to AHU motors. Each of these compartments shall contain CT operated ammeter of 0-20 Amps range with selector switch, auto manual switch along with an ON / OFF indicating lamps and push buttons for status of the pump motors with SP MCB with inbuilt VFD By-Pass 5.5-8 amps TPN MPCBs, 35 KA, with extended handle for 5 HP VFD.

AHU Motors # 1 Nos. 3.5-5 amps TPN MPCBs, 35 KA, with extended handle with power contactor for 3 HP VFD for outgoing feeders to AHU motors. Each of these compartments shall contain selector switch, auto manual switch along with an ON / OFF indicating lamps and push buttons for status of the pump motors with SP MCB.

Humidifier # 4 Nos. (3+1), 11-16 amps TPN MPCBs, 35 KA, with extended handle with power contactor. Each of these compartments shall contain , auto manual switch along with an ON / OFF indicating lamps and push buttons for status of the pump motors with SP MCB.

10	Supply, laying testing and commissioning of 1100 volt grade armored XLPE. insulated and sheathed aluminium Power conductor cables of sizes as below, on cable trays with suitable clamps, saddles, hooks, bolts etc. complete as per specifications and as required. The quoted rate shall include the cost of proper dressing of cables and also providing identification tags as required. Brand\model shall be approved by the engineer incharge.		
10.1	3 core 16 Sq. mm Al cable (33.10E-x)	RM	120
10.2	4 core 10 Sq. mm Al cable (33.10E-xxxiv)	RM	75
10.3	4 core 16 Sq. mm Al cable (33.10E-xxxv)	RM	60
10.4	4 core 25 Sq. mm Al cable (MR)	RM	20
11	Supply, laying testing and commissioning of 1100 volt grade armored XLPE insulated and sheathed copper conductor control cables of sizes as below, on existing cable trays including terminations with suitable clamps, saddles, hooks, bolts etc. complete as per specifications and as required. Brand\model shall be approved by the engineer incharge.		
11.1	5 core 1.5 Sq.mm cable	RM	80
11.2	4 core 1.5 Sq.mm cable	RM	100
12	Supplying and Installation powder coated GI perforated type Cable trays manufactured as per the specifications given in the tender including all the tray accessories including supports, bends, anchor fasteners, GI hardware etc. Brand\model shall be		

approved by the engineer incharge.

12.1	300 mm wide x 40mm x 2 mm thick	RM	30
12.2	150 mm wide x 40mm x 1.6 mm thick	RM	20
13	Supply and Erection of 25mm x 3mm thick copper tape (As additional length). (33.14-xiv)	RM	50
14	Supply and Erection of 8 SWG 4mm dia copper wire (As additional length).(33.14-xviii)	RM	20
15	Supply installation Testing ad commissioning of Suitable capacity Variable Frequency drives with Differential pressure sensor to regulate the speed of motors catering to clean room and semi clean room area.	Nos	3

TOTAL CARRIED TO SUMMARY

G.TOTAL