

The HEPA filter must be EN1822:2009 classification H13/14

GENERAL CONSTRUCTION OF FILTERS

- 1 Factory assembled filter section containing pre-filters made of cleanable metal viscous filters made of corrugated aluminium wire mesh, or dry cleanable synthetic filters. These shall be minimum 50 mm thick with a framework of aluminium/GI.
- 2 The filter area shall be made up of panels of size convenient for handling. The filter panels shall be held snugly within suitable aluminium framework made out of minimum 1.6 mm GI/ aluminium sheet with sponge neoprene gaskets by sliding the panels between the sliding channels so as to avoid airleakage.
- 3 In order to indicate the condition of these filters while in operation, a manometer of suitable range shall be provided to indicate the pressure drop across the fine filters and absolute filters.
- 4 Special filters, if any specified in the tender specifications shall be provided in addition to the above filters. In that event, the latter shall function as pre-filters.
- 5 Filters to be made in contained environment. i.e. in clean room environment
- 6 Air filters shall be HEPA grade standard capacity air filters with waterproof micro glass fiber media, corrugated aluminium separators, urethane sealant, extruded aluminium frame and neoprene sealing gasket
- 7 The media shall be waterproof and re retardant.
- 8 During the pleating, the 180° turn forming each pleat of the media on both sides of the filter shall be wedge-shaped, i.e. the media shall be double scored to form a box fold around the flattened ends of the separator. The uniform t of the wedge-shaped box fold is required to prevent media damage.
- 9 The media pack shall be thoroughly sealed into the inside of the cell sides to prevent bypass leakage around the pack. The polyurethane sealant shall totally encapsulate the media edges closing off all leakage paths.
- 10 Pleat spacing shall be precisely maintained using corrugated aluminium separators permitting maximum usage of media and minimum resistance.
- 11 The filter shall be listed by Underwriter Laboratories as UL Classified.
- 12 The filter shall have a tested efficiency of 99.995% @ MPPS for H13 or above when evaluated according to EN 1822:2009.
- 13 Each HEPA filter shall be individually auto-scan tested before it leaves the factory. Actual data shall be indicated on the filter's label. Each filter shall have its unique serial number

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 Serial No :- 11D14A5

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The filter testing method shall be as per ASHRAE 52.2 latest edition. Efficiency of fine filters shall be in accordance with ISO:16890 and UL listed.
 Shall be suitable for the required duty conditions.

ELECTROSTATIC PRECIPITATOR / ELECTRONIC AIR CLEANER TECHNOLOGY

It is the intent of the specification to incorporate highly efficient electronic air filtration system with low pressure drops into the building AHU/TFA/ HRU system.

The Electronic Air Cleaner system (complete with washable pre-filter, charging section and collector section) along with modular UV Lamp solution to be installed before the cooling coils. The electronic air cleaner (EAC) shall can remove particulates as small as 0.3 microns including microscopic haze particles, smoke, dust, mould spores and bacteria. The UV emitters shall be installed upstream of AHU between the coil section and media filters to improve indoor air quality and to keep the cooling coils clean without the need for regular chemical cleaning. This is to ensure maximum cooling coil heat transfer efficiency to save energy.

PERFORMANCE / RELIABILITY REQUIREMENTS

The EAC filtration to be certified as minimum MERV13/14 or above as per ASHRAE 52.2-2017 from a reputed laboratory.

The proposed equipment shall be capable of capturing sub- micron particulates/contaminants down to 0.3 microns. All tenderers shall submit test results of filtration efficiency by Air Filter Testing Laboratories for efficiency verification.

The solid-state power supply shall provide dual voltage to the ionizer and collector section. The voltage to the ionizer should not be more than 6400V DC to create an intense electrostatic field to allow maximum transfer of electrical charge from the ionizing wires to air particles. The voltage to the collector should not be less than 4000V DC.

For the EAC to perform effectively against PM 1/2.5 pollutants, the EAC shall have a fractional efficiency test report from a third-party testing laboratory to confirm CME (Composite Minimum Efficiency) of the following:

Particle Size	CME
0.3-0.4µm	68% or more
1.0-1.3µm	78% or more
2.2-3.0µm	85% or more

The entire Filtration system shall be washable and reusable without need for replacements. Electrostatic media filters that collect particles on disposable media pads shall not be acceptable.

The average initial pressure differential drop across the entire filtration system shall not exceed 70 PA at 2.5 m/s airflow velocity. The tungsten ionizing wires and collector plates shall be integrated within one pack. It shall be washable for repeated use. A washable aluminium mesh pre-filter shall be provided at the inlet to trap all larger sized particles.

Filter cells shall be universal to allow for a single inventory of filters as spare parts.

The EAC shall be completed with Hot- dipped Galvanized cabinet to protect against rust, heavy duty commercial used electronic cells, solid state power supply, protective screen and pre-filter. A washable aluminium mesh pre-filter shall be provided at the inlet to trap all larger sized particles.

The EAC shall have the capability for the optional addition of activated carbon (Charcoal)/ Chemical filter.

The activated carbon filter shall be able to reside into the EAC cabinet as and when necessary; no modification for the initial installation shall be allowed. The thickness of active carbon filter should not be thinner than 30mm.

SAFETY PROVISIONS

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- Each EAC cell shall have their automatic interlock switch which disconnects power and discharges the cell when the access door is opened. In addition, the EAC shall be capable of interlocking when disconnecting the power to each individual EAC unit, or when the AHU fan is not running.
- A high voltage test button shall be provided for each individual high voltage supply unit to indicate the presence of high voltage on the electronic cells. There should be an alarm or a safety switch inbuilt which can cut off the supply once the air handler is open for maintenance.
- The leakage current shall be lower than 1mA and test report of actual current leakage shall be provided to confirm conformance. Flexible high voltage control is requested to reduce the arcing and protect power board.

CERTIFICATION/ APPROVALS / CODE REQUIREMENTS FOR EAC

- The EAC shall be Underwriter Laboratories (UL) Listed. The EAC shall also be EMC (Electromagnetic compatibility) certified. Full documentation must be submitted to confirm compliance to the above requirements.
- Filtration should comply to ISO 16890-2017
- The EAC shall be CE certified and be qualified with EMC & LVD certified. The certification report shall be provided to confirm conformance.
- Ozone level of EACs provided must be within the acceptable limit of 0.05ppm. Tenderers must also provide a test report to confirm conformance.
- ANSI / ASHRAE 52.2 latest edition

UVGI SYSTEM

The UVC emitters shall be of high UVC energy output type and be effective in destroying pathogens (viruses, bacteria and fungi), allergens (bacteria & mould) and toxins (endotoxins & mycotoxins) under cold moving air conditions.

The UVC emitters must be suitable for recirculation ahu's as per duty conditions.

The UVC emitters and fixtures are to be installed in sufficient quantity and in such an arrangement so as to provide the uniform distribution of UVC intensity on the Coil Fins & surface.

WORKING PRINCIPLE:

Following are minimum design requirement of UVC emitters.

- Emitters and supporting fixtures shall be installed upstream and / or downstream of the cooling and /or heating coil to ensure desired effect.
- Emitters shall be installed at right angles to cooling coil fins such that UVC energy shall bathe all surfaces of the coil and drain pan.
- UVC assembly shall include high efficiency electronic UVC source, housing with reflectors and associated control and power wiring. The same shall be single unit.
- Units shall be high output, suitable for operation in HVAC system and germicidal operation. Units shall be factory assembled and tested.
- Emitters shall be double / single ended as per manufacturer's standard. Double ended units shall have connectors on both sides to simplify gang wiring. Emitters shall be high output T5 (15mm) or T6 (16mm) diameter with four pin type and capable of producing 95% of their energy at 254nm wavelength. Emitters shall be UL certified as per UL 1995 with high PF and operate on 230V, 50Hz, 1-phase supply and capable of lighting up at operating temperatures between 35 Deg. F & 170 Deg. F in airflow upto 1000 FPM. Unit shall be equipped with RF and line noise suppression. Emitters shall not produce ozone or other secondary contamination. Emitter shall be suitable for universal application (Horizontal or Vertical installation).

- Emitters shall be tested at the manufacturer's factory with solid state Photodiode UV sensor at rated distance as per installation for calibration wavelength of 254nm with + 10% accuracy.
- Reflector shall be constructed of high spectral reflectivity with minimum 85% reflectance of 254nm UVC energy.
- Humans are not supposed to come in direct contact with UVC energy rays. For UVC system installed within AHUs, interlock switch shall be provided at the AHU door to cut-off power supply in case of door being opened. Relevant caution stickers shall be installed on all access doors.
- Manufacturer shall submit necessary technical documentation for the above and certification of the product as per ASHRAE / ISHRAE / accredited Indian laboratory for the same
- The emitters shall be of Quartz High output, low pressure mercury germicidal UV-C @ 254 nm wavelength and comply with UL 1995 standard suitable for installation in Air Handling Units/ TFA Units/ Duct installation.
- Emitter life should not be less than 9,000 hours of continuous operation without any drop in its emitting efficiency.
- The UV system shall be designed to provide enough required UV Dosage of at Coil section.
- In addition, the UV Lamps net Wattage density should be greater than 0.8 inch per watt of UV-C produced.

The UVC emitters shall be of high UVC energy output type and be effective in destroying pathogens (viruses, bacteria and fungi), allergens (bacteria & mould) and toxins (endotoxins & mycotoxins) under cold moving air conditions. Conventional UVC emitters which are not capable of producing high UVC energy output under such harsh conditions will not be accepted.

UV HOUSING AND POWER SUPPLY

The proposed UV system shall be modular with modules rated suitable for required air flow CFM. The modules should interconnect with each other. The UV system shall be factory fabricated and plug and play type with possibility of interchangeability if needed. Maximum wattage per system shall not exceed 60Watts. The UV system should be having a support sliding arrangement for easy maintenance. The framework and support for the UV system shall be fabricated out of GI. All parts should be corrosion resistant. Reflector used shall be made of Aluminium.

The power supply for the UVC emitters shall use 230V single phase AC supply, low pressure instant start with power factor greater than 0.9. Lamp driver shall be a part of the enclosure housing UV Lamps.

SAFETY NOTICE

- UVGI system installation arrangements should be such that which must avoid any contact of Irradiate directly to human skin and eyes.
- Avoid directly irradiating to plastic and rubber parts.
- UV light shall be interlocked with fan operation.
- Change the germicidal lamp regularly.

ACTIVATED CARBON FILTER

General

High efficient Activated Carbon (Charcoal) filter shall be provided for the removal of TVOC, gaseous contaminants and odours. The activated carbon filter shall be able to reside into the EAC cabinet as and when necessary; no modification for the initial installation shall be allowed.

SPECIFICATIONS

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- Material: Carbon impregnated foam, 30 PPI, 150% AO.
- Media: Activated Carbon with Synthetic fibre
- Frame: SS and Extruded aluminium
- .014 Thick, 22 Gram/Ft² Aluminium face grid, one side only as shown face grid must not extend beyond edge of frame.
- Frame to be tin plated
- Reduces Sulphur Dioxide, Nitrogen Dioxide, Ozone, Ammonia and other harmful chemical gasses.
- Comprised of very high Activated Carbon Granules, Impregnated Activated Alumina with KMnO₄ and other proprietary chemicals HS Cannablend Select, etc
- Energy Efficient Design
- Corrosion-Free Construction
- “Air entering side”, to be permanently marked on side shown.
- Each filter to be individually sealed in plastic bag.
- 0.25 Water Gauge Max Airflow resistance at 750 CFM
- Efficiency

SO _x	-	Less than 10 µg/m ³
NO _x	-	Less than 10 µg/m ³
O ₃	-	Less than 25 µg/m ³

Note:

- Bidder has to utilize the above mentioned technologies to achieve the desired threshold values ensuring min. pressure drop etc.
- Bidder may propose for alternative solutions/design on site basis only (not general rule) along with the design parameters, drawings, comparative analysis and other documents, as desired by EESL. The cost of the filtration system will remain same as the quoted price. No extra cost will be payable.
- Bidder has to take prior approval of design & technology from EESL before planning for way forward.
- EESL may or may not accept the alternative proposal.

Other SITE SUPPORT AND COMMISSIONING

Vendor shall supply installation support on site when needed to ensure all components are installed properly and functioning at start-up.

Vendor shall have local distributor capable of technical support, trained on all aspects of gas phase including photo-catalytic and dynamic chemistry operations.

The housing construction shall be qualified and tested in accordance with the requirements of DW/143 and certified to have a minimum rating of Class B at negative pressure.

Housing: SAH shall have a corrosion resistant casing consisting of a rigid coated steel and structural frame and 25/50 mm thick double wall insulated panels.

The filter enclosure shall include side-access extruded-aluminium tracks to support the gas-phase filter cassettes. No ductwork / plenum installation or simple ‘L’ track or angle support is permitted.

Access doors shall be provided on the all Sections to allow ease of access to, and installation and removal of, all the filter stages.

IAQ MONITORING SYSTEM

IAQ Monitoring system shall be comprised with integrated display units along with requisite sensors.

- IOT Based Real time monitoring system for Thermal Comfort and Indoor Air Quality Parameters.

- Monitoring & Display of Temperature and Relative Humidity along with Indoor Air Pollutants such as Carbon Dioxide, Volatile Organic Compounds, formaldehyde, Particulate matter of size 2.5 and PM10. Further, yearly sample collection and reporting of Carbon Monoxide, Ozone and Microbial Counts and get it tested in laboratory and submit the report to EESL.
- Solution enables customers to garner points as per IGBC Healthy Building/ WELL Standard.
- AQ Analyzer enables demand based ventilation resulting in energy saving.
- The application provides complete analysis and recommendation to maintain World class Indoor Air Quality.
- The IAQ Monitor must be BMS compatible and must be capable of getting connected over Wi-Fi to send data to a central cloud that is accessible from any device.
- The IAQ monitoring system shall be used to ensure the appropriate system design and achieved performance even in the most hostile outdoor conditions.
- The end users should be able to see the information from any remote location in a user-friendly manner.
- Report Generation with daily, weekly and yearly trend analysis.
- The following parameter shall be displayed through the IAQ monitoring system screen

Description	Parameters	Range
Thermal Parameter	Temperature in °C	-10 to 50 °C
Thermal Parameter	Relative Humidity in %	0 – 99% RH
IAQ Parameter	CO2 in ppm	0 – 3000 ppm
IAQ Parameter	TVOC in ppm	1 - 30 ppm
IAQ Parameter	Formaldehyde in mg/m ³	0-1 mg/m
IAQ Parameter	PM 2.5 in µg/m ³	1.0-2.5 µg/m ³
IAQ Parameter	PM 10 in µg/m ³	2.5-10 µg/m ³

DATA DISPLAY

FEATURE OF MONITOR

The display unit shall be coloured >7" inch TFT, touch screen, web enabled to monitor all the field perimeters. Display shall have android / OS. Display shall be DIN-mounted. Display shall have USB 2.0, HDMI ports to communicate with master controller or gateway.

- Connection: Wi-Fi (2.4Ghz) approx., Ethernet
- Data Logging: approx. 8GB of on-board memory compatible with the dashboard
- External Storage: Cloud-based, Micro-SD card, USB
- Log Interval: 1 minute, 1 hour, 1 day
- Battery: 5000mAh approx.
- Input Voltage: DC - 5V
- Easy swappable sensors

The software subscription shall allow access of data from all monitors consolidated into one platform. The salient features required for the dashboard are listed below:

- Should allow for addition of unlimited number of Monitors
- Historic data should be stored during the duration of the subscription plan
- Display Average of AQI of all Monitors at one place
- Display Average of AQI of Monitors segregated for each floor/campus
- Consolidated view of real-time data of all Monitors along with the details of their placement in the Building
- Consolidated view of the details of the status of the battery and connection of all Monitors

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- Graphical representation of all thresholds that are being met
- Allow download of data reports for any date range
- Plot graphs for custom dates and compare monitors
- Allows views of plotted graphs for a day or a week
- Allows for any number of accounts to be created to access the monitors
- Allows sharing of monitors with Admin or Viewer access with other people in the Organization
- Allows to set or modify working hours so as to view averages and data pertinent to the time spent indoors
- Allows for thresholds to be set based on the efficacy of the Filtration System such that alert emails can be sent out if exceeded
- Should provide API access

DATA STORAGE & DATA TRANSFER

- Data should be stored both locally and on the Cloud to ensure continuous data collection, with and without Internet connectivity.
- Should have Industry standard SSL/TLS encryption which ensures that the data is always safe. Sensor itself must be secured with password protection and customized user permissions.
- Sensor should support both Wi-Fi and Ethernet, as well as data export over email, micro-SD card and USB. Must support range of networks and security options, including proxy servers, hidden SSIDs and captive portal login.
- Must support BACnet allowing it to connect directly to the BMS for enhanced IoT automation and control.

SENSORS & FIELD DEVICES

All Field Instruments / Sensors to have the following:

- Should be CE/UL Certified.
- Should have individual serial numbers with calibration and traceability certificates.
- Should have option of site calibration and validation.
- All Sensors should work on 24VDC Supply, unless specified explicitly.
- Storage Temperature Shall be at least -40 to 85 deg C unless specified explicitly.
- All Certificate (from certified labs) copies to be submitted for approval.

TEMPERATURE SENSORS:

General Requirements:

- Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
- All Sensors should have a 4 – 20mA / 0 – 10VDC Output and should work on 24VDC.
- The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD, 10KNTC type II.
- The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
- All sensors should have CE Rating.
- The storage temperature should be -40 to 85 °C minimum.
- Sensor accuracy shall be for Temp Element $\pm 0.2^{\circ}\text{C}$
- PIR Sensing shall have minimum 94 Angular Degrees up to a Distance of 6 m for wall mounting.

TEMPERATURE & HUMIDITY SENSORS:

- Sensors shall be provided with a sampling chamber. Probe material should comply with UL94-V0 flammability rated per UL 94 standard.
- The Sensor shall be tested and calibrated with equipment certified to be in compliance with National Institute of Standards and Technology (NIST) guidelines.
- 14-30 VDC ambient temperature rating of 50 deg. C, protection class IP65 and Pt 1000 sensing element with 4 to 20mA Output.
- All Polymer Humidity Sensor shall provide Humidity Element accuracy better or equal to $\pm 2\%$ RH for the entire span of 0 to 100% RH at 25 deg C.
- The Sensor shall also provide Temperature accuracy of ± 0.2 deg C or better.
- Humidity sensor's drift shall not exceed 0.5% of full scale per year.
- Survival Operating Conditions range for the sensor shall be -40 deg C to 100 deg C & 0- 100% RH.

OUTSIDE AIR TEMPERATURE & HUMIDITY SENSORS:

Outside Air Relative Humidity & Temp Sensor shall follow IP 65 Housing classification & have CE rating. The Sensor shall be easily mounted on a roof, pole, or side of a building.

- Relative Humidity Analogue Output 0 – 10 VDC / 4 – 20mA for 0 to 100% RH. All Polymer Humidity Sensor shall provide Humidity Element accuracy better or equal to
- $\pm 2\%$ RH for the entire span of 0 to 100% RH at 25 deg C.
- Temperature Sensor shall be Platinum 1000/100, NTC 10K Type II IEC751, Class A, Accuracy at 0°C shall be $\pm 0.2^\circ\text{C}$ with 4 to 20mA Output
- Humidity sensor's drift shall not exceed 0.5% of full scale per year. Warm-Up Time should be Instantaneous.
- Storage Temperature should be -40 to 85 deg C
- Power supply needed 24VDC

DUCT / WALL MOUNT CO2 SENSOR:

- CO₂ Sensor shall have UL94-V0 flammability rated enclosures.
- The Sensor shall have on Micro-Machined Construction for Duct environment. The Sensor shall also consist diffusion-aspirated, single-beam, dual-wavelength NDIR technology.
- The sensor shall have Measuring Range of 0 to 2,000 ppm CO₂ & Accuracy of $\pm 3.0\%$.
- The sensor shall have Response Time (0 to 63%) of less than 1 Minute & Warm- up Time of less than 2 minutes. The Sensor shall workable at Airflow Range 0 to 7,500 ft/Minute.
- Typical area coverage should be greater than 350 m²
- The transmitter should have an option of putting altitude correction mandatorily.
- Warm up time should be less than 30 seconds
- The internal NDIR CO₂ sensor should be replaceable.

PM 2.5 SENSORS

- Sensor Type: Light scattering (350 nm)
- Measurable particle size: 0.3 - 2.5 μm
- Range: 1 - 1000 $\mu\text{g}/\text{m}^3$
- Resolution: 1 $\mu\text{g}/\text{m}^3$
- Accuracy: $\pm 10\%$ ($< 30\mu\text{g}/\text{m}^3$: $\pm 3\mu\text{g}/\text{m}^3$)²

TVOC SENSOR

- Sensor Type: MOS

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- Resolution: 1ppb
- Accuracy: ± 15%

All sensors shall be UL listed and CE certified also certificates shall be submitted.

Note:

- All the sensors and monitoring instruments must be provided with each system for getting the desired outcome of all the IAQ parameters
- One display unit shall be coloured with 40" Smart HD LED TV screen, Wi-Fi enabled to display all the field parameters. Display shall have android / OS. Display shall be DIN-mounted. Display shall have USB 2.0 port & HDMI port to communicate with master controller or gateway.
- At least one 40" Smart HD LED TV screen shall be provided each floor and at reception. If more than 2 are required per floor, extra payment shall be made as per the rates approved by EESL. However, repair and maintenance of the system is at the sole risk and cost of the bidder for project period.

TEST METHOD AND MEASUREMENT

The testing for various IAQ elements shall be done continuously on real time basis (per second) as per the reference standard specified below. The measurement equipment, accuracy, uncertainty of measurement shall conform to requirement as specified in the standards below.

IAQ Parameter Test method and measurement equipment

IAQ element	Test method
CO ₂	ISO 16000-26 Sampling strategy for Carbon dioxide (CO ₂); Note: Except for the screening measurement using sampling tubes, the CO ₂ concentration is recorded continuously using an automatic instrument.
CO	Annex C of ISO 16000-26 Sampling strategy for Carbon dioxide (CO ₂); Note: Except for the screening measurement using sampling tubes, the CO ₂ concentration is recorded continuously using an automatic instrument.
NO ₂	ISO 16000-15 Sampling strategy for Nitrogen dioxide (NO ₂);
Formaldehyde	ISO 16000-3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air – Active sampling method or ISO 16000 – 4: Determination of formaldehyde – Diffusive sampling method
VOCs	ISO 16000 – 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenex TA® sorbent, thermal desorption and gas chromatography using MS or MS-FID
O ₃	ISO 13964: Determination of Ozone in ambient air – Ultra violet photometric Method
PM 10 & PM 2.5	ISO 16000-34: Strategies for the measurement of airborne particles
CH ₂ O**	Shall be measured at least in one location per floor and wing or in one location for each set of rooms with the similar activity. Measurements twice a year once a day (2 results per year), all as a short term measurement.
SO ₂	Shall be measured at the outdoor air intake in to the building (AHU air intake or air vent or open window).

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	In case values of SO ₂ concentration are higher than the specified threshold value as given in section 5.3.1 at air intake, additional measurements need to be taken inside the space.
Total Microbial Count #	Shall be measured in spaces where there are visible signs of moisture damage or where there is a high risk of water leakage. Measurements twice a year once a day (2 results per year), all as a short term measurement.

PARAMETER	SENSOR QUALITY SPECIFICATIONS
CO ₂	Data Output Interval: 1 Min. for each reading max Operating Temp Range: 0-40 °C Operating Range of RH - 10-85% (noncondensing) Measurement Range: 400ppm - 5000ppm Resolution: 5 ppm maximum Accuracy: 400 - 2000ppm: ±5% 2000 - 5000ppm: ±5% Lower Detection Limit - 400ppm Recalibration capability – Required
CO	Data Output Interval: 1 Min. for each reading max Operating Temp Range: 0-40 °C Operating Range of RH: 10-85% (non-condensing) Measurement Range from: 0ppm till 1,500ppm Resolution: 1 ppm maximum Accuracy: 2% of reading Lower Detection Limit - 0ppm Recalibration capability – Required
PM2.5	Data Output Interval: 1 Min. for each reading max Operating Temp Range: 0-40 °C Operating Range of RH - 10-85% (noncondensing) Measurement Range: 0 ug/m ³ to 500 ug/m ³ Resolution: 1 ug/m ³ Accuracy: 0 - 150 ug/m ³ : ±5ug/m ³ 150 - 500 : ±5ug/m ³ Lower Detection Limit - 0 ug/m ³ Recalibration capability – Required
TVOC	Data Output Interval: 1 Min. for each reading max Operating Temp Range: 0-40 °C Operating Range of RH - 10-85% (noncondensing) Installation - should have ability to install permanent Measurement Range: 150 ug/m ³ to 2000 ug/m ³ Resolution of 10 ug/m ³ Accuracy: 150 - 600 ug/m ³ : ±20ug/m ³ 600 - 2000 : ±20ug/m ³ Lower Detection Limit - 150 ug/m ³ Recalibration capability – Required

Note: Bidder shall have to ensure that all the above threshold values are maintained. Furthermore, AQI level of indoor air environment must be in good condition always, irrespective of outdoor conditions.

TREATED FRESH AIR UNIT

TYPE

The TFA shall be single stream unit without any heat or energy recovery system shall be in double skin construction, comprising of supply air section.

The supply air section of TFA shall include the following sections as defined in the Schedule of Equipment: Fresh Air Inlet Damper, space provision for pre-filter, fine filter, 8 row deep Cooling Coil (CHW or DX) Section, Inspection Section, Fan section comprising Supply Air plug fan and EC motor

The HRU units shall be two stream units in double skin construction, comprising of supply air section, return air section, passive dehumidification Wheel and Heat Recovery Section.

The supply air section of HRU shall include the following sections as defined in the Schedule of Equipment: Fresh Air Inlet Damper, pre-filter, fine filter, Enthalpy Wheel, passive dehumidification Wheel, and 8 row deep Cooling Coil Section, Inspection Section, Fan section comprising Supply Air plug fan and EC motor.

The Return Air section shall include the following sections: Return Air inlet damper, pre-filter, Enthalpy Wheel passive dehumidification Wheel, and Fan section comprising of Exhaust air plug Fan with EC motor.

CASING

Double skinned panels shall be 2” thick made of galvanized steel, pressure injected with foam insulation (density 40 kg/m³) with K factor not exceeding 0.02 Watt/Mc shall be fixed to 1.5 mm thick aluminium alloy twin box section structural framework with stainless steel screws. Outer sheet of panels shall be made of galvanised pre-plasticised sheet of 0.8 mm thick, and inner sheet of 22 Gauge plain G.I. Sheet. The entire framework shall be mounted on an aluminium alloy or galvanized steel (depending on size) channel base as per manufacturer’s recommendation. The panels shall be sealed to the framework by heavy duty ‘O’ ring gaskets held captive in the framed extrusion. All panels shall be detachable or hinged. Hinges shall be made of die cast aluminium with stainless steel pivots, handles shall be made of hard nylon and be operational from both inside and outside of the unit. Units supplied with various sections shall be suitable for onsite assembly with continuous foam gasket. All fixing and gaskets shall be concealed. The housing shall be so made that it can be delivered at site in total semi knocked down conditions depending upon the requirements. The main framework shall be of suitable structural sections. The entire framework shall be assembled using mechanical joints to make a sturdy and strong framework for various sections. Framework of all heat recovery units shall be made of thermal break hollow extruded aluminium profile. In case of HRU casing design with no contact between inner and outer surface, thermal break profiles can be avoided.

Units shall have hinged, quick opening access door in the fan section and also in filter section where filters are not accessible from outside. Access doors shall be double skin type.

Condensate drain pan shall be fabricated from 18 gage stainless steel sheet with all corners welded. It shall be isolated from bottom floor panel through 25 mm heavy duty TF expanded polystyrene or urethane foam.

SUPPLY AIR SECTION

The supply air section shall comprise of the following:

FAN SECTION

The supply air fan/centrifugal fan section shall be AMCA certified SISW backward curved aerofoil plug fan with High Efficiency external rotor EC (Electronically Commutated) motor, energy optimized for operation for high efficiency and favourable acoustic behaviour.

Centrifugal fan section shall be complete with access door, squirrel-cage induction motor, direct driven arrangement, belt guard and vibration isolators, direction of discharge / rotation, and motor position shall be as per the Approved-for-Construction shop drawings.

The high efficiency Backward curved impeller made of welded aluminium sheet or high performing composite material with external rotor motor balanced together statically and dynamically according to relevant standards. The EC fan should be capable of being fitted in horizontal position in the AHU. Fan impeller shall be mounted on solid shaft supported to housing using heavy duty ball bearings. Fan housing and motor shall be mounted on a common extruded aluminium base mounted inside the fan section on anti-vibration spring mounts or cushy-foot mount. The fan outlet shall be connected to casing with the help of fire retardant fabric. The fan impeller assembly shall be statically and dynamically balanced.

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- a. Housing shall be constructed of 14-gauge sheet steel welded construction. It shall be rigidly reinforced and supported by structural angles. Split casing shall be provided on larger sizes of fans, however neoprene/ asbestos packing should be provided throughout split joints to make it air-tight.
- b. 18 -gauge galvanized wire mesh inlet guards of 5 cm sieves shall be provided on both inlets. Housing shall be provided with standard cleanout door with handles and neoprene gasket. Rotation arrow shall be clearly marked on the housing.
- c. Fan Wheel shall be backward-curved non-over loading type. Fan wheel and housing shall be statically and dynamically balanced. For fans upto 450 mm dia, fan outlet velocity shall not exceed 550 meter/minute and maximum fan speed shall not exceed 1450 rpm. For fans above 450 mm dia, the outlet velocity shall be within 700 meter/minute and maximum fan speed shall not exceed 1000 RPM. High static pressure fan speed shall be as per manufacturer.
- d. Shaft shall be constructed of steel, turned, ground and polished.
- e. Bearings shall be of the sleeve / ball-bearing type mounted directly on the fan housing. Bearings shall be designed especially for quiet operation and shall be of the self-aligning, oil / grease pack pillow block type.
- f. Motor: The Fan motor shall be highly energy efficiency level of minimum IE-3 and suitable for 415±10% volts, 50 cycles, 3 phase AC power supply, squirrel-cage, totally enclosed, fan-cooled motor, provided with class F insulation, and of approved make. Motor name plate horsepower shall exceed brake horsepower by a minimum of 10%. Motor shall be designed especially for quiet operation and motor speed shall not exceed 1440 rpm. The fan & motor combination selected for the particular required performance shall be of the most efficient (smallest horse power), so that sound level is lowest.
- g. Vibration Isolation: MS base shall be provided for both fan and motor, built as an integral part, and shall be mounted on a concrete foundation through resistoflex vibration isolators. The concrete foundation shall be at-least 15 cm above the finished floor level, or as shown in approved-for-construction shop drawings.

HP	POWER FACTOR			EFFICIENCY		
	FL	3/4L	1/2L	FL	3/4L	1/2L
0.50	0.71	0.62	0.50	73.00	73.00	68.00
0.75	0.74	0.64	0.50	78.00	78.00	70.00
1.00	0.76	0.67	0.55	82.50	82.50	77.00
1.50	0.77	0.70	0.57	83.80	83.80	80.00
2.00	0.77	0.70	0.57	85.00	85.00	81.00
3.00	0.82	0.74	0.60	86.40	86.40	84.00
5.00	0.82	0.78	0.63	88.30	88.30	86.00
7.50	0.85	0.80	0.71	89.50	88.50	88.00
10.00	0.86	0.83	0.76	90.30	90.30	89.00
12.50	0.84	0.82	0.73	90.50	90.50	88.00
HP	POWER FACTOR			EFFICIENCY		
	FL	3/4L	1/2L	FL	3/4L	1/2L
15.00	0.85	0.83	0.76	91.50	91.50	89.50
20.00	0.85	0.83	0.76	92.20	92.20	91.00
25.00	0.85	0.82	0.76	92.40	92.40	91.00
30.00	0.85	0.80	0.72	92.80	92.80	92.00
40.00	0.86	0.85	0.80	93.20	93.20	91.00
50.00	0.87	0.85	0.77	93.60	93.60	91.60
60.00	0.88	0.86	0.78	93.90	93.90	91.90
75.00	0.87	0.85	0.78	94.20	94.20	92.80

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In case of VFD driven motor(if specified in the BOQ) Fans shall be centrifugal, forward inclined blades (static pressures based on the total pressure drop and type of filters) and backward inclined blades (static pressure above 70 mmWg). Fans driven by variable frequency drive shall be backward inclined irrespective of static pressure value. Fans shall be selected for minimum efficiency of 75%. Fan casing shall be made of galvanised steel sheet. Fan wheels shall be made of galvanised steel. Fan shaft shall be grounded C40 carbon steel and supported in self-aligning plummer block operating less than 75% of first critical speed, grease lubricated bearings. Fan wheels and pulleys shall be individually tested and precision balanced dynamically. Fan motor assembly shall be statically and dynamically balanced to G6.3 grade as per relevant ISO/AMCA standard. Computerized fan selection print outs shall be submitted along with the offer. Both fan and motors assemblies shall be mounted on a deep section aluminium alloy or galvanised steel (depending on size) base frame.

Combination spring and rubber anti vibration mounts shall be provided for isolating the unit casing. Frame retardant, waterproof silicone rubber impregnated flexible connection shall be provided at the fan discharge.

MOTOR AND DRIVE

EC Fan motors shall be highly energy efficient (IE-3) and shall be 415±10% volts, 50 cycles, three phase, totally enclosed fan-cooled class F, with IP-55 protection. Motors shall be especially designed for quiet operation and motor speed shall not exceed 1440 rpm. Direct drive to fan motor arrangements shall be provided.

FILTER SECTION

Detailed filter specification can be referred from previous section Air Filtration.

The filter elements shall be mounted on rails and shall be easily pulled out for replacement. The rails shall be provided with efficient gaskets to minimize the risk of leakage.

DAMPER SECTION

Dampers shall be opposed blade type. Blades shall be made of double skinned aerofoil aluminium sections with integral gasket and assembled within a rigid extruded aluminium alloy frame. All linkages and supporting spindles shall be made of aluminium or nylon, turning in teflon bushes. Manual dampers shall be provided with a bakelite knob for locking the damper blades in position. Linkages shall be extended wherever specified for motorised operation. Damper frames shall be sectionalised to minimise blade warping. Air leakage through dampers when in the closed position shall not exceed 1.5% of the maximum design air volume flow rate at the maximum design air total pressure.

COOLING COIL SECTION

The cooling coil shall be made from seamless solid drawn copper tubes. Coils shall have 12.5 to 15 mm dia (O.D) tubes minimum 0.5 mm thick with sine wave aluminium fins firmly bonded to copper tubes assembled in zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across the coil shall not exceed 150 meters per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with chilled water supply & return connections protruding out of AHU casing by minimum 150 mm and fitted with dielectric coupling for connection with MS pipes. Each coil shall be factory-tested at 21 kg per sq.m air pressure under water. Tube shall be hydraulically / mechanically expanded for minimum thermal contact resistance with fins. Fin spacing shall be 4 - 5 fins per cm. Water pressure drop in coil shall not exceed 10 PSIG.

The fins shall be of aluminium. The minimum thickness of the fins shall be 0.15 mm nominal. The no. of fins shall not be less than 4-5 per cm length of coil. Fins may be of either spiral or plate type. The tubes shall be mechanically expanded to ensure proper thermal contact between fins and tubes. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned. For coastal areas fins shall be phenolic coated and for 100% FA application fins shall be hydrophilic type.

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The coil shall be suitable for use with the refrigerant specified or with water as the case may be. Refrigerating coils shall be designed for the maximum working pressure under the operating conditions. Water coils shall be designed for a maximum working pressure of 10kg./sq.cm. Shut off and regulating valves at the inlet and outlet of water shall be provided. In the case of DX coils, solenoid valve and expansion valves shall be provided at the inlet of coil. Computerized cooling coil selection output shall be submitted. All TFA/ HRU AHU's shall be provided with minimum 8 row cooling coil or suitable for desired output. Computerized cooling coil selection output shall be submitted. Coil rating shall be as per AHRI-410/2006. Note: Bidder need to provide the provision (as mentioned above) and cost for the systems such as cooling coils need not be incorporated.

INSPECTION SECTION

The Inspection section shall be for inspection of other functional sections. It shall be available in two options; long and short version and shall be selected as defined in the Bill of Quantities.

RETURN AIR SECTION

The return air section shall comprise of Exhaust air fan section (specifications shall be same as supply air fan as specified in the above section) & separate Section for Waste Heat Recovery Units & Energy Efficiency Units

THE CASSETTE / CASING

The recovery wheel cassette/casing shall be manufactured from corrosion resistant tubular / sheet metal structure to provide a self supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt. The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimising the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration. The face and radial seals shall be four (4) pass non-contact labyrinth seals / brush seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring long life of the seals. Bearings: the bearing shall be permanent lubricated corrosion resistant Stainless steel or self lubricating engineering plastics. Drive Mechanism: The unit shall be provided with complete drive mechanism having drive motor, drive belt and auto belt tension.

HEAT RECOVERY UNIT REHEAT SECTION: SENSIBLE WHEEL/Plate Type Heat Exchanger

Wheel : The wheel shall be made of alternate layer of corrugated and intervening flat composite material of aluminium foil of uniform width to ensure smooth surface. The wheel medium should be bonded together to form rigid transfer medium forming a multitude of narrow channels ensuring laminar flow. The wheels shall be of proven design. The wheel can be fully wound or on larger units, sectorised, i.e. assembled in segments. In latter case the segments are assembled between rigid spokes thus ensuring structural longevity and allowing replacement of one or specific segments only. The wheel shall be cleanable by spraying its face surface with compressed air, low temperature steam or hot water or by vacuum cleaning without affecting its latent properties. The face velocity across the wheel should not exceed 700 fpm (3.5 m/s). The wheels shall be tested in accordance with ASHRAE S4-78 method of testing air to air heat exchangers. Development an manufacturers shall meet all quality assurance criteria specified in BSEN ISO 9001. Necessary controls & instrumentation to ensure supply air conditions shall be responsibility of HRU supplier. The minimum sensible efficiencies should be 75%. A computerized selection should be enclosed along with offer.

HEAT RECOVERY SECTION: (ENTHALPY WHEEL)

Enthalpy wheels shall have minimum recovery of 75 % of total heat, i.e both sensible and latent(each being 75 %). The recovery of sensible and latent shall be equal. Necessary computerized selection of the wheel should be provided along with the bid to justify the same. The wheel shall be made of pure aluminium foil coated with molecular sieve desiccant with pore diameter of 30Å. The cross contamination between the two air streams shall be nil and leakage less than 0.04%. The vertical and radial run of the wheel shall be less than 1 mm per meter of diameter. The wheels shall have non contact labyrinth seals for effective sealing between the two air streams.

Detailed specification for the wheel shall be “HEAT RECOVERY WHEEL” as follows

The substrate: The substrate or wheel matrix should be only of pure aluminium foil so as to allow.

a) quick and efficient uptake of thermal energy.

b) sufficient mass for optimum heat transfer

c) maximum sensible heat recovery at a relatively low rotational speed of 20 to 25 rpm.

- Non-metallic substrates made from paper, plastic, synthetic or glass fibre media, will therefore, not be acceptable.
- The substrate shall not be made from any material which is combustible or supports combustion like synthetic fibrous media.
- The wheel has to be certified as per DIN EN ISO 846 with 0% fungal and bacterial growth at 95% Relative humidity and above.
- The wheel should be AHRI & UL certified
- The minimum depth of the Wheel shall be 250 mm.

Pressure drop:

The pressure drop across the rotary heat exchanger shall not exceed 0.1 inch for every 100 FPM face velocity, or part thereof, for the minimum stated/ required latent recoveries / efficiencies

NECESSARY SOFTWARE SELECTION OF THE WHEEL HAS TO BE ENCLOSED TO JUSTIFY THE PRESSURE DROP

AND EFFICIENCY CALCULATIONS

Casing : The casing shall be constructed as a single skin, self-supporting, galvanized sheet steel structure and include rotary wheel support beams and purging sector. The casing shall be supplied with access panels to facilitate inspection and service. Size 2150 mm and larger shall be in two sections to facilitate shipping and handling.

Seals : The casing shall be equipped with adjustable brush seals, which minimize the carryover to max 0.05 – 0.2%.

Hub and Spokes : Hub and Spokes on one piece rotor shall be Aluminium and on sectorized rotor Hub shall be made of steel, painted with anti corrosion paint and galvanized sheet steel spokes.

Drive : The wheel shall be belt driven along its perimeter. A constant speed fractional horsepower motor shall be used. The motor shall be mounted on a self-adjusting base to provide correct belt tension.

HEAT RECOVERY UNIT DESICCANT BASED

The desiccant should be water molecule selective and non-migratory.

The desiccant should be molecular sieve 3Å (Ecosorb 300), so as to keep the cross contamination to absolute minimum and also ensure the exclusion of contaminants from the air streams, while transferring the water vapour molecules.

The desiccant, of sufficient mass which should not be less than 5 kg per 1000 cfm of air, should be coated with non-masking porous binder adhesive on the aluminium substrate so as to allow quick and easy uptake and release of water vapour. A confirmation has to be provided by manufacturer of wheel to this effect. A matrix with desiccants impregnated in non-metallic substrates, such as synthetic fibre, glass fibre, etc. will not be accepted.

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Rotor: With optimum heat and mass through matrix formed by desiccant, of sufficient mass, the rotor should rotate at lower than 20 to 25 RPM, thereby also ensuring long life of belts and reduced wear and tear of seals. The rotor honeycomb matrix foil should be so wound and adhered as to make a structurally very strong and rigid media which shall not get cracked, deformed etc. due to change of temperature or humidity. The rotor having a diameter upto 2800 mm shall have spokes to reinforce the matrix. From 2000 mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available.

Sectioned wheels, with pie segments, capable of being assembled in the field, shall be available as an option, above 2000 mm in diameter.

The surface of the wheel/rotor should be highly polished to ensure that the vertical run out does not exceed + 1 mm for every 1 metre diameter, thereby ensuring, negligible leakage, if labyrinth non-contact seals are provided, and minimal drag, if contact wiper seals are provided.

The radial run out also shall not exceed + 1 mm for every 1-meter diameter, thereby minimising the leakage/drag on the radial seals, and minimise the fluctuation in the tension of the drive belt.

The number of wraps for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face.

The media shall be cleanable with compressed air, or low pressure steam or light detergent, without degrading the latent recovery.

TESTING

The Thermal Wheel shall be tested in accordance with the parameters fixed as below.

- Supply Air Capacity - FDB/FWB.
- Exhaust Air Capacity - FDB / FWB.
- Fresh Air Capacity - FDB / FWB

OUTDOOR CONDENSING UNIT FOR DX CIRCUIT IN HWU/AHU

The air cooled outdoor unit shall be factory assembled, weather proof casing constructed from heavy gauge mild steel panels with powder coated finish and meet BEE 5 star rating criteria. Each condensing unit shall be complete unit with hermetic compressor/s, air cooled condenser, condenser fans with motors, internal piping, switches and internal wiring and shall be enclosed in a corrosion resistant, epoxy coated weather proof outdoor type housing.

All outdoor units above 5 HP rating shall have minimum two number scroll compressors. In case of outdoor units with multiple compressor, the operation shall not be disrupted with failure of any compressor. And the compressors shall be suitable for eco-friendly refrigerant R-410a or equivalent

The noise level shall not be more than 60 dB (A) at normal operation measured horizontally 1m away and 1.5 m above ground level.

The outdoor unit shall be modular in design with possible future expansions.

The unit shall be provided with microprocessor control panel.

The optimum capacity control shall be of multiple compressors in accordance with load.

The unit shall include a remote control assembly with thermostat and starting and speed switches.

The necessary charge of refrigerant gas and lubricated oil shall be provided to run the system.

COMPRESSOR

The compressor shall be high efficiency scroll type and capable for capacity controlling. It shall change the speed / refrigerant mass flow rate in accordance to the variation in cooling load requirement. Refrigerant mass flow rate can be changed by speed modulation of compressor / mechanical control system. System shall incorporate liquid sub-cooling mechanism with liquid injection at intermediate pressure.

The inverter if used, shall be IGBT (insulated gate bipolar transistor) type for efficient and quiet operation.

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All outdoor units shall have multiple steps of capacity control to meet load fluctuation and indoor unit individual control. All parts of compressor shall be sufficiently lubricated. Forced lubrication may also be employed.

The casing shall be fabricated from galvanized steel zinc phosphate and finished with epoxy coating. The casing shall make the whole unit fully weatherproof, suitable for outdoor installation on the sea side.

Oil heater shall be provided in the compressor casing.

HEAT EXCHANGER

The Heat Exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fan coil and larger surface area.

The condenser coil shall be air cooled type with aluminium fins and copper tubes and necessary refrigerant connections. The copper tubes shall not be less than 1/2" O.D.

The fins shall have anticorrosion treatment for Heat Exchanger Coil. The treatment shall be suitable for areas of high pollution, moisture and salt laden air.

The casings, fans, motors etc. shall also be with anticorrosion treatment as a standard features.

The unit shall be provided with necessary number of direct driven low noise level propeller type fans arranged for vertical / horizontal discharge. Each fan shall have a safety guard.

The condenser air fans shall be propeller type direct driven, each complete with motor. The air quantity and area of the condenser shall be adequate for working in the specified outdoor conditions.

REFRIGERANT CIRCUIT

The Refrigerant Circuit shall include an liquid receiver /accumulator, liquid & gas shut off valves and a solenoid valve. All necessary safety devices shall be provided to ensure the safety operation of the system.

SAFETY DEVICES

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

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

PIPING

All connections of Refrigerant piping shall be in high grade Copper of Refrigeration quality with Eddy Current Testing and material test Certificates.

All connections, tees, reducers etc. shall be standard make fittings.

Insulation of cold lines shall be carried out with nitrile rubber insulation sheets and tubes of appropriate thickness so that condensation does not occur.

For individual Piping 50 / 100 mm wide Aluminium Tape shall be used at joints of Piping with Bands for identification.

For outdoor piping, the finish shall be woven GRP Mat finished with coloured Epoxy paints to withstand outside ambient conditions and UV Radiation.

OIL RECOVERY SYSTEM

Unit shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping. System shall be designed for proper oil return to compressor along with the distribution of oil to individual compressor.

The refrigerant piping shall be extended upped 100 M with 50-M level difference without oil traps.

ELECTRICAL INSTALLATION

For Variable Refrigerant flow systems or DX Outdoor condensing system, power will be provided near outdoor unit location. HVAC Contractor to provide suitable distribution panel along with 3-phase power to outdoor units and single phase power to all indoor units fed by these outdoor units. Power / control cabling along with supports shall be included.

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AIR DISTRIBUTION

SCOPE

This chapter covers the general requirements for sheet metal ductwork for air distribution with associated items such as air outlets and inlets, fresh air intake and fire dampers.

MATERIAL

RECTANGULAR DUCTS

- All ducts shall be fabricated either from Galvanized Sheet Steel (GSS) conforming to IS: 277 or aluminium sheets conforming to IS: 737. The steel sheets shall be hot dip galvanized with coating of minimum 120 grams per square meter (GSM) of Zinc.
- All sheet metal connections, partitions and plenums required for flow of air through the filters, fans etc. shall be at least
- 1.25 mm thick galvanized steel sheets, in case of G.I. sheet ducting or 1.8 mm thick aluminum sheet, in case of aluminum sheet ducting and shall be stiffened with 25mm x25 mm x 3 mm angle iron braces.
- Circular ducts, where provided shall be of thickness as specified in IS: 655 as amended upto date.
- Aluminium ducting shall normally be used for clean room applications, hospitals works and wherever high cleanliness standards are functional requirements.

GAUGE, BRACING BY DUCT SIZE

The thickness of sheets for fabrication of rectangular ductwork shall be as per SMACNA. The thickness required corresponding to the longest side of the rectangular section shall be applicable for all the four sides of the ductwork.

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

For Ducts with external SP upto 250 Pa

Rectangular Ducts G. S.	Pressure 250 Pa		
	Duct Section Length 1.2 m (4 ft)		
Maximum Duct Size	Gauge	Joint Type	Bracing Spacing
1-500 mm	26	C&S Connector	Nil
501 - 750 mm	26	C&S Connector	Nil
751 - 900 mm	26	TDF Flange	Nil
901 - 1200 mm	24	TDF Flange	Nil
1201 - 1500 mm	22	TDF Flange	Nil
1501 - 1800 mm	22	TDF Flange	JTR or ZEE BAR
1801 - 2100 mm	20	TDF Flange	JTR or ZEE BAR
2101 - above	18	TDF Flange	JTR or ZEE BAR

For Ducts with external SP upto 500 Pa

Rectangular Ducts G. S.	External Pressure 500 Pa		
	Duct Section Length 1.2 m (4 ft)		

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Serial No : 11014A5

Maximum Duct Size	Gauge	Joint Type	Bracing Spacing
1-400 mm	26	C&S Connector	Nil
401-700 mm	24	C&S Connector	Nil
701-900 mm	24	TDF Flange	Nil
901-1000 mm	22	TDF Flange	Nil
1001-1200 mm	22	TDF Flange	JTR or ZEE BAR
1201-2100 mm	20	TDF Flange	JTR or ZEE BAR
2101-above	18	TDF Flange	JTR or ZEE BAR

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

FLAT OVAL/ROUND SPIRAL DUCTS

- All Flat Oval/ Round Spiral Duct and Fittings shall be manufactured from 180 gsm galvanized steel of lock forming quality.
- All Flat Oval/ Round Spiral Ducts should have in Continuous external reinforcement with 4-ply Spiral lock seam at regular intervals of 125 mm of maximum length of 3 m each. The fabrication of flat Oval spiral ducts & duct fittings should be as per SMACNA High pressure duct standards, 1985.
- All Flat Oval/ Round Spiral Ducts and Duct fittings shall be joined with slip joint connects of 50mm insertion length and fastened with rivets.

Minimum duct wall thickness shall be as indicated in Table below:-

Flat Oval Duct Gauge

Major Dimension Duct Width (MM)	Longitudinal Seam (GAUGE)	Spiral Seam (GAUGE)	Fitting (GAUGE)
UPTO 600	20	24	20
601 TO 750	20	22	20
751 TO 900	20	22	20
901 TO 1050	18	22	18
1051 TO 1200	18	22	18
1201 TO 1350	18	20	18
1351 TO 1500	18	20	18
1501 TO 1750	16	20	16
1751 & ABOVE	16	18	16

ROUND Duct Gauge

Major Dimension Duct Width (MM)	Seam (GAUGE)	Fitting (GAUGE)
UPTO 600	24	24
601 TO 900	22	22
901 TO 1250	20	20
1251 & ABOVE	18	18

- Reinforcement for oval/ Round duct shall be of the same and spacing interval as specified for rectangular duct or shall be provided to limit wall deflection to $\frac{3}{4}$ in. (19mm) and reinforcement deflection to $\frac{1}{4}$ in (6.4mm).
- Unless otherwise specified, joints and seams shall be similar to those indicated for round duct.
- Fittings shall conform to the thickness schedules in Table, shall conform to the seam, joint, and connection arrangements permitted for round duct, and shall be reinforced to conform to

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- The duct construction shall be capable of withstanding a pressure 50 percent greater than that of the assigned pressure class without structural failure or permanent deformation.
- Duct wall deflection at atmospheric pressure, with reinforcement and connections in place, shall not exceed ¼ in. (6.4 mm) on widths of 36 in. (914mm) or less of ½ in (13 mm) on greater widths. Refer Criteria in Chapter 11 of SMACNA Standards – 2005 Third Edition.
- Supports shall conform to those permitted for rectangular duct, with the overall dimensions taken as references.

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User ID : p.kumar
Serial No : 11014AS

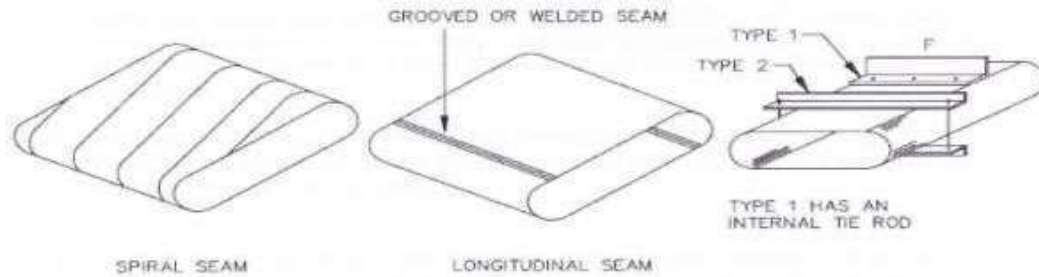


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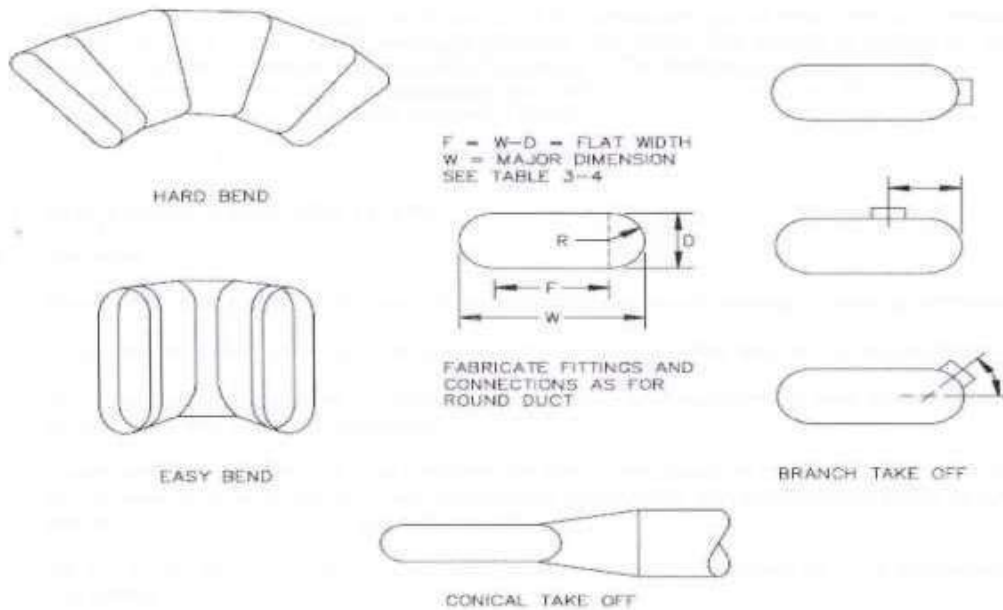
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FLAT OVAL DUCTS
(Refer. Fig.3-7- SMACNA STANDARDS- 2005- THIRD EDITION)



JOINTS AND CONNECTIONS ARE SIMILAR TO ROUND DUCT SIZE REINFORCEMENTS AS FOR RECTANGULAR DUCT OF F DIMENSION ATTACH REINFORCEMENT TO DUCT AT ENDS AND 12" (305 MM) MAX. SPACING



ASSOCIATED ITEMS

- Supply/return air outlets, FA grilles and accessories shall be constructed from extruded aluminum sections.
- Flanges for matching duct sections, stiffening angles (braces) and supporting angles shall be of rolled steel sections, and shall be of the following sizes.

Application	Duct Width	Angle Size
Flanges	Upto 1000 mm	25 mm x25 mm x 3mm
	1001mm to2250mm	40 mm x40 mm x 3mm
	More than2250mm	50 mm x50 mm x 3mm
Bracing	Upto 1000 mm	25 mm x25 mm x 3mm
	More than1000mm	40 mm x40 mm x 3mm
Support Angle	Upto 1000 mm	40 mm x40 mm x 3mm
	1001mm to2250mm	40 mm x40 mm x 3mm
	More than2250mm	Size & type of RS section

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		shall be decided in individual case
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- Hanger rods shall be of mild steel and of at least 10mm dia for ducts up to 2250mm size and 12mm dia for larger sizes.
- All nuts, bolts and washers shall be zinc plated steel. All rivets shall be galvanized or shall be made of magnesium- aluminum alloy. Self-tapping screws shall not be used.

CONSTRUCTION

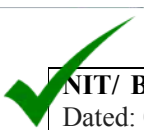
DUCTS

- Ducts shall be fabricated at site or factory fabricated and shall be generally as per IS: 655 "Specifications for metal air ducts", unless otherwise deviated in these General Specifications.
- The interior surfaces of the ducting shall be smooth.
- All the ducts up to 600mm longest side shall be cross broken between flanges by a single continuous breaking. Ducts of size 600mm and above shall be cross broken by single continuous breaking between flanges and bracings. Alternatively, beading at 300mm centers for ducts up to 600mm longest side, and 100mm centers for ducts above 600mm size shall be provided for stiffening.
- As far as possible, long radius elbows and gradual changes in shape shall be used to maintain uniform velocity accompanied by decreased turbulence, lower resistance and minimum noise. The ratio of the size of the duct to the radius of the elbow shall be normally not less than 1:1.5.
- Flanged joints shall be used at intervals not exceeding 2500mm. Flanges shall be welded at corners first and then riveted to the duct.
- Stiffening angles shall be fixed to the sides of the ducts by riveting at 1.2.5 meters from joints for ducts of size 600mm to 1500mm, and 0.6m from joints for ducts of size larger than 1500mm. Bracings for ducts larger than 1500mm can alternatively be by diagonal angles.
- Plenums for filters shall be complete with suitable access door of size 450mm x450mm.
- 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 Customer / consultant.

AIR OUTLET AND INLETS (SUPPLY AND RETURN)

- All air outlets and intakes shall be made of extruded aluminum sections & shall present a neat appearance and shall be rigid with mechanical joints.
- Square and rectangular wall outlets shall have a flanged frame with the outside edges returned or curved 5 to 7 mm and fitted with a suitable flexible gasket between the concealed face of the flanges and the finished wall face. The core of supply air register shall have adjustable front louvers parallel to the longer side to give up to 22.5 degrees vertical deflection and adjustable back louvers parallel to the shorter side to achieve a horizontal spread air pattern to at least 45 degrees. Return air grilles shall have only front louvers. The outer framework of the grilles shall be made of not less than

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- c. 1.6 mm thick aluminum sheet. The louvers shall be of aero foil design of extruded aluminum section with minimum thickness of 0.8mm at front and shall be made of 0.8mm thick aluminum sheet. Louvers may be spaced 18 mm apart.
- d. Square and rectangular ceiling outlets/intakes shall have a flange flush with the ceiling into which it is fitted or shall be of anti-smudge type. The outlets shall comprise an outer shell with duct collar and removable diffusing assembly. These shall be suitable for discharge in one or more directions as required. The outer shell shall not be less than 1.6 mm thick extruded section aluminum sheet. The diffuser assembly shall not be less than 0.80 mm thick extruded aluminum section.
- e. Circular ceiling outlets/intakes shall have either flush or anti smudge outer cone as specified in the tender specifications. Flush outer cones shall have the lower edge of the cone not more than 5 mm below the underside of the finished ceiling into which it is fitted. Anti-smudge cones shall have the outer cone profile designed to reduce dirt deposit on the ceiling adjacent to the air outlet. The metal sheet used for construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.
- f. Linear diffusers shall have a flanged frame with the outside edges returned 3.5 mm and shall have one to four slots as required. The air quantity through each slot shall be adjustable. The metal sheet used for the construction of these shall be minimum 1.6 mm thick extruded aluminum sheet.
- g. Grilles and diffusers constructed of extruded aluminum sections shall have grille bars set straight, or deflected as required. These shall be assembled by mechanical interlocking of components to prevent distortion. These grilles and diffusers shall have a rear set of adjustable blades, perpendicular to the face blades for deflection purposes.
- h. All supply air outlets shall be fitted with a volume control device, made of extruded aluminum gate section. The blades of the device shall be mill finish/ block shade pivoted on nylon brushes to avoid rusting & rattling noise, which shall be located immediately behind the outlet and shall be fully adjustable from within the occupied space without removing any access panel. The volume control device for circular outlets shall be opposed blade radial/shutter type dampers, or two or more butterfly dampers in conjunction with equalizing grid. Opposed blade dampers shall be used for square and rectangular ceiling/ wall outlets and intakes.
- i. All the products supplied by contractor should supplement 'in performance by selection curves of product ratings from the manufacturer.
- j. Laminar supply air diffusers shall be made of 2mm thick powder coated aluminum sheet duly insulated with 5mm thick dosed cell polyethylene foam insulation having factory laminated aluminum foil and joints covered with self-adhesive aluminum tape and having holes 2/3 mm dia including frame work.

FRESH AIRINTAKES

- a. Fresh air intake grills shall be made of extruded aluminum sections.
- b. A flanged frame using RS sections shall be provided on front face to conceal the gap

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between the louvers and the adjoining wall face. Corners of frame shall be welded. The frame shall be made structurally rigid.

- c. Louvers made from extruded aluminum section shall be in modular panel form for ease of handling. These shall be free from waves and buckles. Vertical blades shall be truly vertical and horizontal blades shall be truly horizontal. Butt joints in blades shall not be accepted.
- d. Additional intermediate equally spaced supports and stiffeners shall be provided to prevent sagging/vibrating of the louvers, at not more than 750mm centers where the louver's length is longer than 750mm.
- e. A bird wire screen made of 12 mm mesh in 1.6 mm steel wire held in angle or channel frame shall be fixed to the rear face of the louver frame by screens.

DAMPERS

- a. Dampers : All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
- b. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
- c. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.
- d. Pressure relief dampers: Pressure relief dampers shall be constructed with 18G Aluminium construction with parallel blade construction. Leafs shall be 100% air tight upon closure. Leafs shall be loaded with spring pressure of stiffness (k value) corresponding to set point pressure.
- e. Non return damper (Back draft damper) : Non return damper shall be constructed out of 16G GSS. Blades shall ensure 100% air leak proof performance on closure. Design shall ensure that no rattling noise is produced at design duty.

FIRE & SMOKE DAMPERS

- a. Fire dampers shall be provided in all the supply air ducts and return air ducts (where provided), return air passage in the air-handling unit room and at all floor crossings. Access door will be provided in the duct before each set of fire dampers.
- b. Fire dampers shall be multi blade louvers type. The blade should remain in the air stream in Open position & shall allow maximum free area to reduce pressure drop & noise in the air passage. The blades and frame shall be constructed with minimum 1.6mm thick galvanized sheet & shall be factory fitted in a sleeve made out of 1.6mm galvanized sheet of minimum 400mm long. It shall be complete with locking device, motorized actuator & control panel.
- c. Fire dampers shall be motorized smoke & fire dampers type. Fire damper shall also close on receipt of fire alarm signal to cut off air supply instantaneously. An electric limit switch

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shall also be operated by the closing of fire damper, which in turn shall switch off power supply to AHU blower motor as well as strip heaters.

- d. Fire dampers shall be CBRI tested & certified for 90 minutes rating against collapse & flame penetration as per UL 555- 1995 (Underwriters Laboratories)
- e. Fire dampers shall be compatible with the fire detection system of building & shall be capable of operating automatically through an electric motor on receiving signal from fire alarm panel.
- f. Necessary wiring from fire alarm panel up to AHU electric panel shall be provided by the department & further from AHU electric panel to fire damper shall be provided by air conditioning contractor.
- g. Each damper shall be provided with its own control panel, mounted on the wall and suitable for 240 VAC supply. This control panel shall be suitable for spring return actuator and shall have at least the following features:
 - Potential free contacts for AHU fan ON/ Off and remote alarm indication.
 - Accept signal from external smoke / fire detection system for tripping the electrical actuator.
 - Test and reset facility.
 - Indicating lights / contacts to indicate the following status:
 - Power Supply On
 - Alarm
 - Damper open and close position.
- h. Actuators shall be mounted on the sleeve by the damper supplier in his shop and shall furnish test certificate for satisfactory operation of each Motor Operated Damper in conjunction with its control panel. Control panel shall be wall mounted type.
- i. It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.

INSTALLATION OF METALLIC DUCT


FABRICATION STANDARDS & EQUIPMENT

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

- a. Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
- b. 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.
- c. All edges to be machine treated using lock formers, flangers and rollers for turning up edges.

DUCTING

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- a. The fabrication and installations shall be in a workmanlike manner. Ductwork shall be rigid and straight without kinks.
- b. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of Owner's site representative in all its parts and details
- c. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.
- d. If a duct cannot be run as shown on the drawings, the contractor shall install the duct between the required points by any path available in accordance with other services and as per approval of owner's site representative.
- e. All exposed ducts within the conditioned space shall have slip joints. Flanged joints shall not be used.
- f. All joints shall be airtight.
- g. Ducts shall be supported independently from the building structure and adequately, to keep the ducts true to shape. The support spacing shall be not more than 2m. Where ducts cannot be suspended from ceiling, wall brackets or other suitable arrangements, as approved by the Engineer-in-charge shall be adopted. Neoprene or other vibration isolation packing of minimum 6mm thickness shall be provided between the ducts and the angle iron supports/brackets. Vertical duct work shall be suitably supported at each floor by steel structural members.
- h. Where metal ducts or sleeves terminate in woodwork, tight joints shall be made by means of closely fitting heavy flanged collars. Where ducts pass through brick or masonry openings, wooden frame work shall be provided within the openings and the crossing ducts shall be provided with heavy flanged collars on either side of the wooden frame work, so that duct crossing is made leak-proof.
- i. Duct connections to the air-handling unit shall be made by inserting a double canvas sleeve 100 mm long. The sleeve shall be securely bonded and bolted to the duct and unit casing.
- j. Dampers shall be provided in branch duct connections for proper volume control and balancing the air quantities in the system, whether indicated in the drawings or not. Suitable links, levers and quadrants shall be provided for proper operation, control and setting of the dampers. Every damper shall have an indicating device clearly showing the position of the dampers at all times.
- k. Where electrical heaters are mounted in the duct, these shall be of low temperature totally enclosed type fitted with radiation fins. A removable panel for access to the heaters shall be provided in the duct. Any hole in the duct for electrical wiring must be provided with suitable bushes to avoid leakage. 6 mm thick asbestos board lining shall be provided all around the inside of the duct for a distance of 30cm on either side of the electrical heaters. A manually reset thermostatic safety switch shall be provided near the duct section having heaters. In addition, the heaters must be interlocked with the connected fan motor of the AHU.
- l. Ducting over furred ceiling shall be supported from the slab above, or from beams after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All metal work in dead or furred down spaces shall be erected in time to occasion no delay to other contractor's work in the building.

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- m. Where ducts pass through brick or masonry openings, it shall be provided with 25mm thick TF quality expanded polystyrene around the duct and totally covered with fire barrier mortar for complete sealing.
- n. All ducts shall be totally free from vibration under all conditions of operation. Whenever ductwork 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 ductwork 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.
- o. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

AIR OUTLETS AND INLETS

- a. The locations of the air outlets and intakes shall be shown in the tender drawings and necessary openings and the wooden framework for fixing the grilles shall be provided by the air conditioning contractor. The location of these outlets/ inlets is subject to change and the approval of the Engineer-in-Charge shall be obtained before finally fixing the grilles/diffusers in position.
- b. In installing fresh air intakes, no fixing device shall be visible from the face of the frame. Where louvers are to be fixed in masonry or concrete, fixing shall be with either expanding plugs or raw plugs. Where the louvers are to be fixed in steel or wood, non-ferrous screws or bolts shall be used.
- c. Supply air outlets and return air intakes shall be anodized/ powder coated aluminium to the desired colour to match the surroundings wall/ceiling. The fresh air intakes shall be anodized/ powder coated aluminium as approved by the Engineer-in-Charge. The paint colour shall be approved by the Engineer-in-Charge.
- d. All damages to the finish of the structure during the installation work shall be made good by the air-conditioning contractor before handing over the installation to the Department.

BALANCING

The entire air distribution system shall be balanced with the help of an anemometer. The measured air quantities at fan discharge and at the various outlets shall be within ± 5 percent of those specified/ quoted. Branch duct adjustments shall be permanently marked after the air balancing is completed so that these can be restored to their correct position if disturbed at any time.

DOCUMENTATION & MEASUREMENT OF DUCTING

All ducts fabricated and installed should be accompanied and supported by proper documentation viz:

- i. Bill of material/Packing list for every duct section supplied.
 - a. Measurement sheet covering each fabricated duct piece showing dimensions and external surface area along with summary of external surface area of duct gauge-wise.
 - b. 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.

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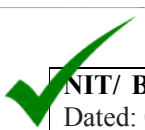


- c. Unless otherwise specified, measurements for ducting for the project shall be on the basis of centerline measurements described herewith
- d. Ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external 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.
- e. 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.
- f. 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.
- g. 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, inspection chamber/access panel, splitter damper with quadrant and lever for position indication, turning vanes, straightening vanes, and all other accessories required to complete the duct installation as per the specifications. These accessories shall NOT be separately measured nor paid for.
- ii. Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith :
 - a. Grilles and registers - width multiplied by height, excluding flanges. Volume control dampers shall form part of the unit rate for registers and shall not be separately accounted.
 - b. Diffusers - cross section area for air flow at discharge area, excluding flanges. Volume control dampers shall form part of unit rate for supply air diffusers and shall not be separately accounted.
 - c. Linear diffusers - shall be measured by cross-sectional areas and shall exclude flanges for mounting of linear diffusers. The supply air plenum for linear diffusers shall be measured with ducting as described earlier.
 - d. 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.
 - e. v. 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.

TESTING

After duct installation, total duct work (Air-conditioning and Mechanical Ventilation Ducts) should be tested for leakage. The procedure for leak testing should be followed as per SMACNA – “HVAC Air Duct Leakage Test Manual” (First Edition – 1985)

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DUCTWORK LEAKAGE TESTS:

This section of the specification describes the ductwork leakage testing procedure.

- a. All ductwork shall be pressure tested for leakage, smoke test is not acceptable. The sub-contractor shall provide the necessary test equipment and skilled labour to carry out the tests satisfactorily.
- b. Tests shall be witnessed and certified by the Client/PMC's representative. Prior to witness of final tests, the sub-contractor shall carry out preliminary tests to ensure the test results are within specified limits.
- c. All duct work shall be tested for leakage without duct insulation or duct enclosure at the joints.
- d. Accuracy of the test apparatus shall be within:
 - e. $\pm 5\%$ of the indicated flow rate or 0.5 l/s, whichever is greater, and
 - f. 5% of the indicated static pressure in duct under test.
- g. The test apparatus shall have a calibration certificate, chart of graph dated not earlier than one year before the test for which it is used.

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ELECTRICAL WORKS

SCOPE

The scope of this section comprises of fabrication, supply, erection, testing and commissioning of Motor Control Centre (MCC), wiring and earthing of all air-conditioning equipment, components and accessories.

Note – Configuration of MCC panels shall be design to suit the requirement of system \ process. Necessary single line diagrams \ GA drawings shall be furnished by contractor for approval by consultant \ owner

GENERAL

Work shall be carried out in accordance with the accompanying specifications and shall comply with the latest relevant Indian Standards and Electricity Rules and Regulations.

All motor control centres shall be suitable for operation on 3 Phase/single phase, 11,000/415/240 volts, 50 cycles, 4 wire system with neutral grounded at transformer. All MCCs be CPRI tested design and manufactured by a approved manufacturer. CPRI certificate be made available.

MCCs comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-8623. MCCs / starter panels for outdoor equipment shall be suitable for outdoor duty application.

CONSTRUCTIONAL FEATURES

The Motor Control Centre (MCC) shall be of 2 mm thick sheet steel cabinet and suitable for indoor installation, dead front, floor mounting/wall mounting type and shall be form 3b construction. The Distribution panels be totally enclosed, completely dust and vermin proof and be with hinged doors and folded covers, Neoprene gasket, padlocking arrangement and bolted back. All removable/ hinged doors and covers shall be grounded by flexible standard connectors. MCC shall be suitable for the climatic conditions as specified in Special Conditions. Steel sheets used in the construction of panels be 2 mm thick and be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding, slag shall be rounded off and welding pits wiped smooth with plumber metal. The general construction confirm to IS-8623-1977 (Part-1) for factory built assembled switchgear & control gear for voltage up to and including 1100 V AC.

All MCCs/panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws enter into holes tapped into an adequate thickness of metal or provided with wing nuts. Self-threading screws not be used in the construction of Distribution panels. A base channel of 75 mm x 40 mm x 5 mm thick shall be provided at the bottom for floor mounted panels. Minimum operating clearance of 275 mm be provided between the floor of panels and the lowest operating height.

The MCC shall be of adequate size with a provision of spare feeders. Feeders be arranged in multi-tier. Knockout holes of appropriate size and number shall be provided in the Motor Control Centre in conformity with the location of cable/conduit connections. Removable sheet steel plates shall be provided at the top/bottom to make holes for additional cable entry at site if required.

Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram mounted on inside of door shutter protected with Hylam sheet. All live accessible connections shall be shrouded and minimum clearance between phase and earth be 20 mm and phase to phase be 25 mm.

Panels with ACB shall necessarily have front and rear access as per requirement whereas panels with all MCCB breaker shall be provided with front access with sufficient clearance.

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WIRING SYSTEM

All control wiring shall be carried out by using PVC insulated copper conductor wires in conduits. Minimum size of control wiring be 1.5 sq mm. Minimum size of conductor for power wiring shall be 4 sq. mm 1100 volts grade PVC insulated copper conductor wires in conduit. All conductors shall be stranded.

CIRCUIT COMPARTMENT

All components for each feeder shall be housed in a separate compartment and have steel sheets on top and bottom of compartment. Sheet steel hinged lockable door be duly interlocked with the breaker in the "ON" position. Safety interlocks be provided to prevent the breaker from being drawn-out when the breaker is in 'ON' position. The door not form an integral part of the draw-out portion of the panel. Sheet steel barriers shall be provided between the tiers in a vertical section.

All MCCs shall be provided with feeders of appropriate capacity as per Single Line Diagram. All MCCs shall be completely factory wired, ready for connection. All the terminals shall be of proper current rating and sized to suit individual feeder requirements. Each circuit be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits be distinctly marked with a small description of the service installed.

Continuous earth bus sized for prospective fault current shall be provided with arrangement for connecting to station earth at two points. Hinged doors/ frames shall be connected to earth through adequately sized flexible braids.

INSTRUMENT ACCOMMODATION

Adequate space shall be provided for accommodating instruments, indicating lamps, control contactors and control MCBs. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker and bus bar 'ON' lamps shall be provided on all outgoing feeders.

BUS BAR CONNECTIONS

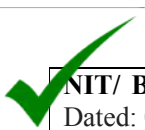
Bus bar and interconnections shall be of high conductivity electrolytic grade aluminium/copper complying with requirement of IS : 5082 – 1981 and of rectangular cross section suitable for carrying the rated full load current and short circuit current and shall be extendable on either side. Bus bars and interconnections shall be insulated with heat shrinkable PVC sleeve of 1.1 KV grade and shall be colour coded. Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connections shall be done by bolting. Additional cross sectional area to be added to the bus bar to compensate for the holes. All connections between bus bars and breakers shall be through solid copper / aluminium strips of proper size to carry full rated current and insulated with insulating sleeves. Maximum current density for the busbars be 0.8 A/sq.mm for aluminium and 1.4 A/sq.mm for copper busbars.

Maximum allowable temperature for the Bus bar to be restricted to 85 deg C

TEMPERATURE - RISE LIMIT

Unless otherwise specified, in the case of external surface of enclosures of bus bar compartment which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per IS 8623(Part-2) 1993.

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CABLE COMPARTMENTS

Cable compartment of adequate size shall be provided in the panel for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports be provided in cable compartment to support cables as per approved for construction shop drawing.

MOULDED CASE CIRCUIT BREAKER (MCCB)

The MCCB should be current limiting type with trip time of less than 10 msec under short circuit conditions. The MCCB should be either 3 or 4 poles. MCCB comply with the requirements of the relevant standards IS13947 – Part 2/IEC 60947-2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

MCCB comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses

The breaking capacity of MCCB be as specified in the Drawings/BOQ. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCBs for motor application should be selected in line with Type-2 Co-ordination as per IEC-60947-2, 1989/IS 13947-2. The breaker as supplied to meet IP54 degree of protection.

CURRENT LIMITING & COORDINATION

The MCCB employ maintenance free minimum let-through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. The manufacturer provide both the discrimination tables and let-through energy curves for all.

PROTECTION FUNCTIONS

- MCCBs with ratings less than and including 200 A shall be equipped with Thermal-magnetic (**adjustable** thermal for overload and **fixed** magnetic for short-circuit protection) trip units
- Microprocessor MCCBs with ratings above 200A and above shall be equipped with microprocessor based trip units.
- Microprocessor and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorized access to the settings
- Microprocessor trip units comply with appendix F of IEC 60947-2 standard (measurement of RMS current values, electromagnetic compatibility, etc.)
- Protection settings apply to all poles of circuit breaker.
- All Microprocessor components withstand temperatures up to 125 °C

TESTING

Original test certificate of the MCCB as per IEC 60947-1 & 2 or IS13947 be furnished.

Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

INTERLOCKING

Moulded, case circuit breakers be provided with the following interlocking devices for interlocking the door of a switch board.

- Handle interlock to prevent unnecessary manipulations of the breaker.
- Door interlock to prevent the door being opened when the breaker is in ON position.
- Defeat-interlocking device to open the door even if the breaker is in ON position.

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The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism. MCCBs shall be capable of defined variable overload adjustment. All MCCBs rated less than and including 200 A and above have adjustable over load & short circuit pick-up . All MCCB with microprocessor based release unit, the protection be adjustable Overload, Short circuit and earth fault protection with time delay. The trip command override all other commands.

MOTOR PROTECTION CIRCUIT BREAKER (MPCB)

Motor circuit breakers conform to the general recommendations of standard IEC 947 -1,2 and 4 (VDE 660, 0113 NF EN 60 947-1-2-4, BS 4752) and to standards UL 508 and CSA C22-2 N°14. The devices shall be in utilization category A, conforming to IEC 947-2 and AC3 conforming to IEC 947-4. MPCB have a rated operational and insulation voltage of 690V AC (50 Hz) and MPCB shall be suitable for isolation conforming to standard IEC 60947-2 and have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without de-rating. Power supply be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers. The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles close, open, and trip simultaneously. The motor circuit breakers accept a padlocking device in the “isolated” position.

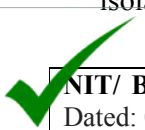
The motor circuit breakers shall be equipped with a “PUSH TO TRIP” device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements be possible. The front-mounting attachments not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or NC. All the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type. The motor circuit breakers have a combination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1. Type 2 co-ordination be guaranteed by tables tested and certified by an official laboratory: LOVAG (or other official laboratory). The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which allow the device setting. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) be factory set to an average value of 12 Ir.

All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 60°C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available. Temperature compensation (-20°C to +60°C)

MINIATURE CIRCUIT BREAKER (MCB)

Miniature Circuit Breaker comply with IS-8828-1996/IEC898-1995. Miniature circuit breakers shall be quick make and break type for 240/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity not be less than 10 KA at 415 VAC. MCBs shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). MCBs shall be classified (B,C,D ref IS standard) as per their Tripping Characteristic curves defined by the manufacturer. The MCB have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer publish the values. MCB ensure complete electrical isolation & downstream circuit or equipment when the MCB is switched OFF.

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The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole miniature circuit breakers have a common trip bar independent to the external operating handle.

PAINTING

All sheet steel work undergo a process of degreasing, pickling in acid, cold rinsing, phosphating, passivating (nine tank processing) and then painted with electrostatic paint (Powder coating). The shade of colour of panel inside/outside shall be as indicated in datasheets & relevant BIS code) RAL 7035 (Siemens Gray).

LABELS

Engraved PVC labels shall be provided on all incoming and outgoing feeder. Circuit diagram showing the arrangements of the circuit inside the control panel shall be pasted on inside of the panel door and covered with transparent plastic sheet.

METERS

- All voltmeters and indicating lamps shall be through MCB's.
- Meters and indicating instruments be plug type.
- All CT's connection for meters shall be through Test Terminal Block (TTB).
- CT ratio and burdens shall be as specified on the Single line diagram.

CURRENT TRANSFORMERS

All phase be provided with current transformers of suitable VA burden with 5 amps secondaries for operation of associated metering.

The CTs conform to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast, robust to withstand thermal and dynamic stresses during short circuits. Metering CTs, have inbuilt busbar mounting arrangement. Secondary terminals of CTs be brought out suitable to a terminal block which be easily accessible for testing and terminal connections. The secondary terminal should be covered with insulation cap/cover so that there should not be any possibility of touching the live terminal. The protection CTs be of accuracy class IP20 and measurement CTs be of accuracy class I.

SELECTOR SWITCH

Where called for, selector switches of rated capacity be provided in control panels, to give the choice of operating equipment in selective mode.

CONTACTOR

Contactors shall be built into a high strength thermoplastic body and shall be provided with an arc shield for quick arc extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and endurance under continuous operation. The magnet system consist of laminated yoke and armature to ensure clean operation without hum or chatter.

Starters contactors have 3 main and 2 Nos. NO / NC auxiliary contacts and shall be air break type suitable for making and breaking contact at minimum power factor of 0.35. For design consideration of contactors the starting current of connected motor shall be assumed to be 6 times the full load current of the motor in case of direct-on-line starters and 3 times the full load current of the motor in case of Star Delta and Reduced Voltage Starters. The insulation for contactor coils be of Class "E".

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Coil shall be tape wound vacuum impregnated and be housed in a thermostatic bobbin, suitable for tropical conditions and withstand voltage fluctuations. Coil be suitable for 220/415±10% volts AC, 50 cycles AC supply.

THERMAL OVERLOAD RELAY

Thermal over load relay have built in phase failure sensitive tripping mechanism to prevent against single phasing as well as on overloading. The relay operate on the differential system of protection to safeguard against three phase overload, single phasing and unbalanced voltage conditions.

Auto-manual conversion facility shall be provided to convert from auto-reset mode to manual-reset mode and vice-versa at site. Ambient temperature compensation shall be provided for variation in ambient temperature from -5° C to +55°C.

All overload relays shall be of three element, positive acting ambient temperature compensated time lagged thermal over load relays with adjustable setting. Relays shall be directly connected for motors upto 35 HP capacity. C.T. operated relays be provided for motors above 35 HP capacity. Heater circuit contactors may not be provided with overload relays.

TIME DELAY RELAYS

Time delay relays shall be adjustable type with time delay adjustment from 0-180 seconds and have one set of auxiliary contacts for indicating lamp connection.

INDICATING LAMP AND METERING

All meters and indicating lamps be in accordance with relevant IS standard specification. The meters shall be flush mounted type. The indicating lamp shall be of LED type. Each MCC and control panel be provided with voltmeter 0-500 volts with three way and off selector switch, CT operated ammeter of suitable range with three nos. CTS of suitable ratio with three way and off selector switch, phase indicating lamps, and other indicating lamps as called for. All indicating lamp be backed up with 5 amps MCB.

TOGGLE SWITCH

Toggle switches, where required, shall be in conformity with relevant IS Codes and be of 5 amps rating.

PUSH BUTTON STATIONS

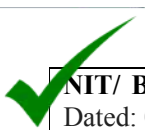
Push button stations shall be provided for manual starting and stopping of motors / equipment Green and Red colour push buttons shall be provided for 'Starting' and 'Stopping' operations. 'Start' or 'Stop' indicating flaps shall be provided for push buttons. Push Buttons shall be suitable for panel mounting and accessible from front without opening door, Lock lever be provided for 'Stop' push buttons. The push button contacts be suitable for 6 amps current capacity.

CONDUITS

Conduits and Accessories conform to latest edition of Indian Standards IS-9537 part 1 & 2. 16/14 (16 gauge upto 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or MS conduits to be used. Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only.

Only approved make of conduits and accessories be used.

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Conduits shall be delivered to the site of construction in original bundles and each length of conduit bear the label of the manufacturer.

Note. : Whatever materials required to be billed by the Contractor should come on site with proper Challan Numbers and quantity mentioned in each such Challan..

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into metallic Conduits are given below :

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	5	10	14	-	-
2.5	5	8	12	-	-
4	3	7	10	-	-
6	2	5	8	-	-
10	--	3	5	6	-
16	--	2	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into rigid non metallic or PVC Conduits are given below :

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

CABLES

1100V grade Cables of sizes 25 sq. mm. and above shall be XLPE FRLS insulated aluminium conductor armoured type and PVC insulated Copper conductor armoured cables for sizes 16 sq. mm. and below. All cables shall be conforming to IS Codes. Cables shall be suitable for laying in trenches, ducts, and on cable trays as required. Cables shall be termite resistant. Cable glands shall be heavy duty double compression brass glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables.

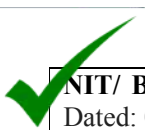
The equipment inside plant room shall be connected to the control panel by means of suitable cables of adequate size. An isolator shall be provided near each motor/equipment (mounted within 10 ~ 15 mtr distance on nearest wall or self supported on floor) wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads shall be provided at both the ends for easy identification of control wiring.

Cables shall be cross linked polyethylene (XLPE) insulated PVC inner sheathed and FRLS PVC outer sheath of 1100 volts grade. Cables shall be suitable for laying in trenches, ducts, and on cable trays as required. Cables shall be termite resistant. Cable glands shall be double compression glands. Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables. All conductors shall be stranded.

Cabling for following equipment shall be fire survival type.

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Basement smoke exhaust fan



- Jet fans
- Smoke evacuation fan
- Staircase, lift, lobby pressurization tank
- Make-up air fan for emergency duty

FIRE SURVIVAL ARMoured CABLE

Fire Survival armoured cable, LPCB / BRE-GLOBAL / ERDA approved, with class -2, annealed copper / or aluminium conductor having glass mica fire barrier tape extruded with cross linkable low smoke zero halogen insulation. The inner & outer sheath shall be LSZH. The basic design shall be as per BS: 7846 & BS: 5839-1 (Latest edition).

The cable should meet fire performance circuit integrity test as per BS 8434-2 / BS 6387 CWZ.

FIRE SURVIVAL UN-ARMoured CABLE

Fire Survival Un-armoured cable, LPCB / BRE-GLOBAL / ERDA approved, with class -2, annealed copper or aluminium conductor having glass mica fire barrier tape extruded with cross linkable low smoke zero halogen insulation. The outer sheath shall be LSZH. The basic design shall be as per BS: 7629 & BS: 5839-1 (Latest edition).

The cable should meet fire performance circuit integrity test as per BS 8434-2 / BS 6387 CWZ. HVAC contractor shall submit cable schedule for all equipment for approval.

CABLE LAYING

Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable.

The cable drums be placed on jacks before unwinding the cable. Great care shall be exercised in laying cables to avoid forming kinks.

Laying of Cables on Cable Trays

The relative position of the cables, laid on the cable tray be preserved and the cables not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturer's. All cables be laid with minimum one diameter gap and shall be clamped at every metre to the cable tray. Cables be tagged for identification with aluminum tag and clamped properly at every 20M. Tags be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable be identified by embossing on the tag the size of the cable, place of origin and termination.

All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint upto one meter on all joints, terminations and both sides of the wall crossings by "VIPER CABLE RETARD".

WIRE AND WIRE SIZES

1100 volts grade PVC insulated copper conductor wires in conduit shall be used.

For all single phase/ 3 phase wiring, 1100 volts grade PVC insulated copper conductor LSZH wires shall be used. The equipment inside plant room and AHU room shall be connected to the control panel by means of insulated copper conductor wires of adequate size in exposed conduits. Final connections to the equipment shall be through wiring enclosed in galvanized flexible conduits rigidly clamped at both ends and at regular intervals. An isolator shall be provided near each motor/equipment wherever the motor/equipment is separated from the supply panel through a partition barrier or through ceiling construction. PVC insulated copper conductor wires shall be used inside the control panel for connecting different components and all the wires inside the control panel shall be neatly dressed and plastic beads be provided at both the ends for easy identification of control wiring.

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The minimum size of control wiring shall be 1.5 sq. mm PVC insulated stranded soft drawn copper conductor wires drawn through conduit to be provided for connecting equipment and control panels.

Power cabling shall be of the minimum following sizes:

- i. Upto 5 HP motors/ 5 KW heaters 3C x 4 sq. mm copper conductor PVC insulated cables.
- ii. From 6 HP to 10 HP motors 3 x 6 sq. mm copper conductor PVC insulated cables.
- iii. From 12.5 HP to 15 HP 2 Nos. 3 x 6 sq. mm copper conductor PVC insulated cables.
- iv. From 20 HP to 25 HP motors 2 Nos. 3 x 10 sq. mm copper conductor PVC insulated cables

STARTERS

Each motor shall be provided with a starter of suitable rating. Starters be in accordance with relevant IS Codes. All Star Delta Starters be fully automatic. Motors up to 7.5 HP be provided by Direct On Line (DOL) starter, motors above 7.5 HP shall be provided by star/delta starter/ Soft starter wherever asked. All starters be with Type II coordination for breaker, contactor and over load relay.

All the switches, contactors, push button stations, indicating lamps be distinctly marked with a small description of the service installed. The following capacity contactors and overload relays shall be provided for different capacity motors or as per manufacturer's recommendation.

CABLE TRAYS

Ladder and perforated type Cable Trays be of Hot dip Galvanized type and factory fabricated out of CRCA sheet with standard accessories like tee, bends, couplers etc. for different loads and number and size of cables as given below :

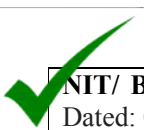
Cable trays be galvanized as per Specifications..

Supply and fixing of perforated type cable trays of the following sizes of pre-galvanized iron.

- a. 300 x 40 x 40 x 2 mm thick
- b. 150 x 40 x 40 x 2 mm thick
- c. 100 x 40 x 40 x 2 mm thick

Note : Suitable length of 10 mm dia GI rod suspenders at 1800 mm interval shall be included in the item for perforated type cable tray.

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VARIABLE FREQUENCY DRIVES FOR HVAC SYSTEMS

GENERAL REQUIREMENTS

- a. This specification covers complete variable frequency drives (VFDs) designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD.
- b. The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered product.
- c. The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.
- d. The VFD shall be tested to UL 508C. The appropriate UL label shall be applied.
- e. The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
- f. The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.

TECHNICAL REQUIREMENTS

- a. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor de-rating.
- b. 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.
- c. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.
- d. VFD shall be with chokes / harmonic filters so as to maintain TH id as per (IEEE519, 1992) as indicated in Schedule of Quantity.
- e. 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 for project electrical single line diagram. Input information like transformer rating, impedance, short circuit current, short circuit impedance, cable sizes and lengths etc. shall be made available to VFD vendor. Cost of such analysis shall be included.
- f. Unless specified otherwise, EMC Filters shall be provided (Integral or externally mounted) for all the Drive Ratings- Category **C2** EMC Filters for complete compliance with EN 61800-3 to confirm to both Conducted (minimum 75 metres) and Radiated Emissions (minimum 75 metres).
- g. If asked for in schedule of quantities, VFDs shall contain EMC Filters (Integral or externally mounted) to attenuate Radio Frequency Interference conducted to the AC power line to comply with the emission and immunity requirements of IEC 61800-3: 2004, Category **C1** with 50m motor cable (unrestricted distribution).
- h. The suppliers of VFDs shall include additional EMC filters if required to meet compliance to this requirement.

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Dated: 03/09/2020

SECTION-4
(Technical& SCC)

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