GALGOTIAS UNIVERSITY

GALGOTIAS UNIVERSITY
ENG. & ADMIN BLOCK

TENDER DOCUMENT
FOR
HVAC (High & Low Side) WORKS

February 2024

:CLIENT:

Smt. SHAKUNTLA EDUCATIONAL & WELFARE SOCIETY
GALGOTIAS UNIVERSITY
PLOT NO. 2, YAMUNA EXPY, SECTOR 17A,
GREATER NOIDA, UTTAR PRADESH -203201, INDIA

:PROJECT MANAGER:

CBRE South Asia Pvt. Ltd | PJM Group - India
6th & 7th Floor | DLF Square Building | Jacaranda Marg
DLF Phase II | Gurgaon 122002, India

: ARCHITECT:

ARCOP ASSOCIATES PVT. LTD.
E-106, GREATER KAILASH ENCLAVE-I
NEW DELHI, INDIA

: MEP SERVICES CONSULTANTS:

SUNIL NAYYAR CONSULTING ENGINEERS LLP
206, 206A, 2nd Floor, Time Centre,
DLF Golf Course Road, Sector-54, Gurgaon-122 002

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SECTION: 1
NOTICE INVITING TENDER

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NOTICE INVITING TENDER

Tender is invited by The Registrar, M/s **SMT SHAKUNTLA EDUCATIONAL & WELFARE SOCIETY, Galgotias University**, **PLOT 02, YAMUNA EXPY, SECTOR 17A, GREATER NOIDA, UTTAR PRADESH** for **HVAC & CHILLER Works Works**, for New Admin & Engg. Block, Greater Noida, Uttar Pradesh.

Bidders to download the Tender Documents and submit the duly filled Tender documents in all respect to **projects.pq@galgotiasuniversity.edu.in** on OR before the date mentioned in the newspaper notification. Please send Pre-Bid queries by email only.

Following Tender Documents are to be submitted by the bidders:

Sl. No	Description	Duly Signed & Stamped
A	Notice Inviting Tender (NIT) & Form of Tender	1 Original (NIT with duly filled-in Form of Tender & Appendix)
B	GCC, SCC & Formats of No Claim Certificate, Articles of Agreement, Indemnity Bond, RBG & Performance Bank Guarantee	1 Original
C	Bill Of Quantities	1 Original
D	Power of Attorney authorizing the signatory of Tender & Contract	1 Original
E	Proposed Methodology of Work	1 Original
F	Proposed Schedule of Work	1 Original
G	List of Plant & Machinery along with Schedule of Deployment at site	1 Original
H	Proposed Site Organization Chart along with Manpower Deployment Schedule	1 Original
I	Details of works in Hand	1 Original
J	Litigation History	1 Original
K	Project Quality Plan	1 Original
L	Environment, Health, and Safety Plan	1 Original

Bidders shall put his stamp and signatures on every page of the Tender including every Tender drawing at the lower right-hand corner.

All the rates mentioned in the tender shall be inclusive of transportation, loading & unloading, government statutory requirement charges, etc., and shall remain firm till completion of work. No escalation of the prices shall be allowed for any reasons whatsoever. GST and Labour Cess shall be mentioned separately.

Bidders are advised to submit the Tenders strictly based on the conditions of contract and specifications contained in the Tender documents and are advised not to stipulate any deviations. Deviations may, however, be stipulated in case of unavoidable circumstances. Exceptions and deviations, which Bidder may desire to stipulate, shall be listed separately. The PMC, client & the Architect reserve the right to reject any such deviations or evaluate the Tender containing deviations having financial implication, by adding the cost for such deviations as may be determined by the PMC or the client or the Architect.

We intend to adhere to a very strict timeline in administering this Tender.

Proposals received beyond the mentioned time and date will not be considered.

Incomplete responses shall be liable to be disqualified at GALGOTIAS UNIVERSITY's sole discretion.

This Notice Inviting Tender shall form part of the contract.

For,

SMT SAKUNTALA EDUCATIONAL & WELFARE SOCIETY
Galgotias University

Authorized Signatory

SECTION: 2
FORM OF TENDER

FORM OF TENDER

To,
SMT SAKUNTLA EDUCATIONAL & WELFARE SOCIETY
Galgotias University
PLOT 02, YAMUNA
EXPY, SECTOR 17A,
GREATER NOIDA,
UTTAR PRADESH,
INDIA-203201

Dear Sir,

Having examined the conditions of contract, specifications, Tender drawings and Bill of quantities relating to the works specified in the Tender hereinafter set out and having examined the site of the works specified and having acquired the requisite information relating thereto as affecting the tender, I/We hereby offer to execute the works specified, within the time specified & at the rates mentioned in the attached bill of quantities and in accordance, in all respect, with the specifications, designs, drawings and instructions in writing referred to the GCC, SCC, Technical Specifications & (Tender drawings) of the said Tender.

Should this tender be accepted, I/We hereby agree to abide by and fulfil the terms and provision of the said conditions of Contract as per Tender document to so far as they may be applicable or in default thereof to forfeit and pay to **Galgotias University,** the amount as per the said conditions.

I/We have deposited Earnest Money Deposit (If applicable) in the form of Bank Guarantee in favour of **Galgotias University** as specified in Appendix to Form of Tender. Should I/We fail to execute the contract when called upon to do so, I/We do hereby agree that this sum shall be forfeited by **Galgotias University.**

All information and documents as required to be submitted as per Tender Document are enclosed.
Our banker(s) (Name & complete address):

The names of partners of our firm are:

1.

2.

Name of the partner of the firm
authorized to sign OR

Name of person having Power of Attorney to sign the Tender & Contract (Certified true copy of the Power of Attorney shall be attached)

Yours faithfully,

Signatures of Tenderer Stamp Name & Address

i. Witness 1 (Signatures, Name & Address):

ii. Witness 2 (Signatures, Name & Address):

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SECTION: 3
PRE-QUALIFICATION (attached separately)

SECTION: 4

GENERAL CONTRACT CONDITIONS

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General Conditions of Contract (GCC)

1. **DEFINITIONS & INTERPRETATIONS**

1.1. **Definitions**

The following words and expressions shall have the meanings hereby assigned to them, except where the context otherwise requires:

(a) "**Acceptance Defects Notice**" has the meaning given to it in Clause 11.3.(c).

(b) "**Affiliate**" means any entity which directly or indirectly:

(i) owns or Controls such entity;

(ii) is owned or Controlled by such entity;

(iii) is under common ownership or Control with such entity.

(c) "**Affected Party**" has the meaning given to it in Clause 31.1.

(d) "**Applicable Law"** means, with respect to any Governmental Authority, national, regional or local law, directive, statute, rule, regulation, ordinance, treat, order, decree, judgment, decision, determination, interpretation, certificate, injunction, registration, license, permits, authorization, guideline, approval, consent or requirement of/by such Governmental Authority, as construed from time to time by any Governmental Authority.

(e) "**Application for Change Proposal**" has the meaning given to it in Clause 22.4(a).

(f) "**Approved List**" has the meaning given to it in Clause 16.2.

(g) "**Architect**" means the person/entity appointed as the architect for the Project by the Client and as notified by the Client to the Contractor pursuant to Clause 13.1.

(h) "**Bid**" has the meaning given to it in the Instructions to Bidders.

(i) "**Bidding Documents**" means the Notice Inviting Bids ("**NIB**"), Tender Drawings, Instructions to Bidders ("**ITB**"), Drawings, Technical Specifications, Bid Forms, Technical Bid, Price Bid, Contract and General Conditions of Contract ("**GCC**").

(j) "**Change**" has the meaning given to it in Clause 22.1.

(k) "**Change in Law"** has the meaning given to it in Clause 32.1.

(l) "**Change Order**" has the meaning given to it in Clause 22.3(e).

(m) "**Change Proposal**" has the meaning given to it in Clause 22.3(a).

(n) "**CIBIL**" means Credit Information Bureau (India) Limited.

(o) "**Codes and Standards**" means the codes and standards as more fully detailed in the Technical Specifications, in relation to the design, specification, construction, fabrication and inspection of the New admin. & Engg. Block.

(p) "**Commencement Date"** has the meaning given to it in Clause 7.1.

(q) "**Completion**" has the meaning given to it in Clause 11.1(a).

(r) "**Completion Certificate**" has the meaning given to it in Clause 11.1(b).

(s) "**Completion Date**" has the meaning given to it in Clause 7.2(a).

(t) "**Contract**" means (i) the Contract Agreement; (ii) GCC; (iii) Technical Specifications; and (iv) any other documents listed in the Contract Agreement.

(u) "**Contractor**" means Who has been awarded the Work.

(v) "**Contract Agreement**" means the agreement to be executed on [__] between the Contractor and the Client in the form set out in **Schedule II** for undertaking and completing Works with respect to the Project including all annexures and schedules, as the same may be amended, supplemented or modified from time to time by mutual written agreement. [***input the date of execution of the Contract.***]

(w) "**Contract Price**" has the meaning given to it in Clause 23.1.

(x) "**Contract Schedule**" has the meaning given to it in Clause 5.22(b).

(y) "**Contractor's Equipment"** means all appliances, things or equipment of whatsoever nature required for the execution and completion of the Works and the remedying of any defects therein.

(z) "**Contractor's Personnel**" means the Contractor's Representative, Works Manager and each individual and collectively the Contractor's employees, labour (skilled, semi-skilled and unskilled) Sub-Contractors, and

their respective employees, contractors (of the Sub-Contractors), officers, licensees, invitees, agents and representatives, who are provided and/or utilized by Contractor for the execution of the Works and any other personnel notified to the Client by the Contractor as the Contractor's Personnel.

(aa) "**Contractor's Representative**" means the person identified in Clause 5.23.(a), or the replacement of such Person who is nominated and approved in accordance with the procedure provided in Clause 5.23.(d).

(bb) "**Control**" means (and related terms shall refer accordingly to), with respect to any person, (i) the possession, directly or indirectly, of the power to direct or cause the direction of the management and policies of such person whether through the ownership of voting securities, by agreement or otherwise or the power to elect more than one-half of the directors of such person; or (ii) the possession, directly or indirectly, of a voting interest of more than 50% (fifty percent); or (iii) the power to veto decisions of such person, whether through ownership of voting securities, by contract, or otherwise;

(cc) "**Defects Notice**" has the meaning given to it in Clause 11.1(c).

(dd) "**Defect Liability Period**" has the meaning given to it in Clause 21.2.

(ee) "**Dispute**" has the meaning given to it in Clause 35.2.

(ff) "**Documents**" means the data in the form of text, worksheets, Drawings (including as-built drawings) designs, specifications, plans or reports in print or electronic form and complying with the requirements of the Technical Specifications, to be submitted by the Contractor, in relation to the Works required for developing the New admin. & Engg. Block, including but not limited to engineering data, ELECTRICAL AND ELV and construction drawings, documents required to satisfy all regulatory approvals and other such descriptive material as specified under the Technical Specifications.

(gg) "**Drawings**" means the drawings for the New admin. & Engg. Block including for the ELECTRICAL AND ELV and structural Works required to build the New admin. & Engg. Block and as referred to in the Technical Specifications and any modification to such drawings as approved by the Client, Architect and Project Manager and such other drawings as may, from time to time be provided by the Client to the Contractor.

(hh) "**Environmental Standards**" means Applicable Law, codes, rules and regulations relating to: (a) pollution, contamination, clean-up, protection and reclamation of the environment; (b) health or safety, including, without limitation, the exposure of employees or other persons to any Hazardous Materials; (c) the release or threatened release of any Hazardous Materials; (d) the management of any Hazardous Materials, including, without limitation, the manufacture, generation, formulation, processing, labelling, distribution, introduction into commerce, registration, use, treatment, handling, storage, disposal of materials, the discharge of chemicals, gases or other substances or materials into the environment, the presence of such materials, chemicals, gases or other substances in or around the New admin. & Engg. Block, transportation, reuse, recycling or reclamation of any Hazardous Materials; and (e) any governmental approval issued by a Governmental Authority with respect to the foregoing.

(ii) "**Final Acceptance Certificate**" has the meaning given to it in Clause 11.3.(b).

(jj) "**Final Completion**" has the meaning given to it in Clause 11.3.(a).

(kk) "**Force Majeure Event**" has the meaning given to it in Clause 31.1.

(ll) "**Governmental Authority**" means any Indian national, regional, state, municipal or local government, and any division, ministry, department, agency or other emanation of any of the same, including any judicial body, commission, board, branch or similar authority of such government and anybody empowered to

grant, withdraw or determine the terms and conditions of any applicable permit and the organs of the Government of India or as the case may be, the Government of the Indian State where the Site is located.

(mm) "**Hazardous Materials**" means (i) any element, compound, substance, preparation, chemical, physio-chemical properties or biological derivative, radiation, noise, vibration, material or combination thereof which by reason of its composition or characteristics is defined in Applicable Law as a hazardous material, or (ii) any other material which any Government Instrumentality determines from time to time is harmful, toxic, or dangerous, or otherwise ineligible for handling, storage or disposal by unregulated means or is liable to cause harm to human beings, other living creatures, plant, micro-organism, property or the environment.

(nn) "**Indemnified Party**" has the meaning given to it in Clause 28.3.

(oo) "**Indemnifying Party**" has the meaning given to it in Clause 28.3.

(pp) "**Information**" has the meaning given to it in Clause 29.1.

(qq) "**Intellectual Property**" means any licenses, permissions or agreements from licensors of any materials, goods, processes, methods and systems incorporated or to be incorporated in the New admin. & Engg. Block, proprietary information, patents, trademark rights, technology, utility model, registered design, know-how, trade secrets, data bases, industrial processes, source codes, copyrights (including rights in computer software) and any other intellectual or industrial property rights (whether registered or unregistered) subsisting or recognised under the Applicable Law or laws of any other applicable jurisdiction.

(rr) "**Invoice**" has the meaning given to it in Clause 24.4(a).

(ss) "**Instructions to Bidders (ITB)**" means the instructions to bidders issued by the Client or Project manager as part of the Bidding Documents in relation to the Works to be completed by the Contractor dated 07th December 22 bearing no. RMH-ELECTRICAL AND ELV-001.

(tt) "**KMP**" means the key managerial personnel as defined under the Companies Act, 2013.

(uu) "**Latent Defect**" has the meaning given to it in Clause 21.12.(a).

(vv) "**Letter of Award (LOA)**" means the formal acceptance in writing by the Client by way of registered letter or by email notifying the Contractor that its bid has been accepted.

(ww) "**Losses**" has the meaning given to it in Clause 28.1.

(xx) "**Materials**" means and includes all the materials required for undertaking the Works including ELECTRICAL AND ELV works and activities required for developing the Project and building the New admin. & Engg. Block.

(yy) "**Miscellaneous Invoice**" has the meaning given to it in Clause 24.4.(j).

(zz) "**Notice Inviting Bids (NIB)**" means the notice inviting bids issued by the Client as part of the Bidding Documents in relation to the Works to be completed by the Contractor dated 7th December 22 bearing no. RMH-ELECTRICAL AND ELV-001.

(aaa) "**Notice of Completion**" has the meaning given to it in Clause 11.1.(a)(iv).

(bbb) "**Notice of Final Completion**" has the meaning given to it in Clause 11.3.(ix).

(ccc) "**Notice of Provisional Acceptance**" has the meaning given to it in Clause 11.2.(a).

(ddd) "**Occupancy Certificate**" means the final occupancy certificate for the New admin. & Engg. Block issued by Governmental Authority certifying the New admin. & Engg. Block can be occupied and used for its intended purpose.

(eee) "**Pending Agreement Change Order**" has the meaning given to it in Clause 22.3.(i).

(fff) "**Performance Bank Guarantee**" has the meaning given to it in Clause 3.1.

(ggg) "**Performance Parameters**" has the meaning given to it in Clause 9.

(hhh) "**Price Bid**" has the meaning given to it in the Instructions to Bidders.

(iii) "**Prohibited Payment**" has the meaning given to it in Clause 36.9(a).

(jjj) "**Project**" means the development, construction and operation of the New admin. & Engg. Block by the Contractor, located at the Site.

(kkk) "**Project Manager**" has the meaning given to it in the Instructions to Bidders.

(lll) "**Provisional Acceptance**" has the meaning given to it in Clause 11.2(a).

(mmm) "**Provisional Acceptance Certificate**" has the meaning given to it in Clause 11.2(b).

(nnn) "**Provisional Defects Notice**" has the meaning given to it in Clause 11.2.(c).

(ooo) "**Prudent Industry Practices**" means the practices, methods, techniques and standards, as they may be modified from time to time, which are generally followed in the ELECTRICAL AND ELV Works industry; including those expected from a reasonably skilled, prudent and experience person engaged in Works for completion of buildings and performing works and services and providing and supplying equipment and materials as required to be performed or supplied by the Contractor, Sub-Contractors, their employees and other third party agents of the Contractor under the Contract.

(ppp) "**Public Official**" has the meaning given to it in Clause 36.9.(b).

(qqq) "**Purpose"** has the meaning given to it in Clause 29.2.

(rrr) "**Quality Assurance Programme"** has the meaning given to it in Clause 8.2 and means the quality assurance programme as approved by the Client and as set out in the Technical Specifications.

(sss) "**Quality Engineer"** has the meaning given to it in Clause 5.35(d)(i).

(ttt) "**RBI**" means the Reserve Bank of India.

(uuu) "**Request for Change Proposal**" has the meaning given to it in Clause 22.3(a).

(vvv) "**Safety Officer**" has the meaning given to it in Clause 5.35(d)(ii).

(www) "**Serial Defect**" has the meaning given to it in Clause 21.13(a).

(xxx) "**Site**" means all parcels of land on which the New admin. & Engg. Block has to be built and developed as shown in **Schedule XVII**.

(yyy) "**New admin. & Engg. Block**" means the New admin. & Engg. Block to be built on the Site based on the designs and drawings provided by the Architect and other specifications as provided for and detailed under the Technical Specifications, which shall without limitation, include.

(zzz) "**Sub-Contractor**" means any person, including vendor of the Contractor to whom execution of any part of the Works is contracted by the Contractors and includes their successors or permitted assignees.

(aaaa) "**Successful Bidder**" has the meaning given to it in the Instructions to Bidders.

(bbbb) "**Take Over**" means the handing over of the New admin. & Engg. Block by the Contractor to the Client, pursuant to Clause 11.4, pursuant to the issuance of a Take Over Certificate.

(cccc) "**Take Over Certificate**" means the certificate issued by the Client pursuant to Clause 11.4.

(dddd) "**Taxes**" include all taxes, duties, cesses, imposts, fees, levies (including without limitation, all central, state and local government taxes, octroi, excise duties, customs duties, sales tax, countervailing duties, value added tax, works contract tax, service tax, building and construction workers cess and withholding taxes on income) imposed under any Applicable Law (whether within India or outside India) in connection with the Works, the Project, the Parties or performance by the Contractor/Sub-Contractor of its obligations and responsibilities under the Contract.

(eeee) "**Technical Bid**" has the meaning given to it in the Instructions to Bidders.

(ffff) "**Technical Specifications**" means the technical specifications attached to the Contract.

(gggg) "**Work Product**" has the meaning given to it in Clause 30.1.

(hhhh) "**Works**" means the works and services as set out in the Technical Specifications laid down into the Contract, to be executed by the Contractor in relation to the New admin. & Engg. Block and the Project, in accordance with the terms of the Contract. Works shall also include works to be executed by the Contractor under the Contract, which are contracted by the Contractor to the Sub-Contractor(s).

(iiii) "**Works Manager**" has the meaning given to it in Clause 5.23(h).

1.2. **Interpretation**

(a) Reference to the singular shall include reference to the plural and vice-versa and a reference to any gender shall include a reference to the other genders, except where the context otherwise requires.

(b) The headings and marginal notes in the Contract are included for ease of reference, and shall not affect the meaning or the interpretation of the Contract.

(c) The Schedules and Technical Specifications to and of the Contract form an integral part of the Contract and will be of full force and effect as though they were expressly set out in the body of the Contract.

(d) Unless the context otherwise requires, a reference to any Article, Clause, recital and Schedule shall be to an Article, Clause, recital and Schedule of the Contract respectively.

(e) Reference to any law or regulation having force of law includes a reference to that law or regulation, as from time to time, amended, modified, supplemented, extended or re-enacted.

(f) Reference to time shall, except where the context otherwise requires, be construed as a reference to Indian Standard Time. Any reference to calendar shall be construed as reference to the Gregorian calendar.

(g) The words "include" or "including" shall be deemed to be followed by "without limitation" or "but not limited to" whether or not they are followed by such phrases.

(h) In case of any discrepancy between words and figures, the words shall prevail over the figures.

(i) The provisions of all the documents comprising the Contract and the Documents shall be interpreted harmoniously and only if the provisions of the said agreements and documents cannot be interpreted harmoniously with each other on account of inconsistencies or ambiguities then, unless expressly stated otherwise in the Contract Agreement, the priority of the documents shall be in accordance with the following sequence; (i) the Contract; (ii) GCC (iii) Technical Specifications; and (iv) any other documents listed in the Contract.

(j) Whenever provision is made for the giving of notice, approval or consent by any Person, unless otherwise specified, such notice, approval or consent shall be in writing and the words "notify" and "approve" shall be construed accordingly.

(k) Provisions including the word "agree", "agreed", "agreement" require the agreement to be recorded in writing.

(l) The terms "written" or "in writing" means hand-written, type-written, printed or electronically made, and resulting in a permanent record.

(m) When any timeframe in terms of number of days is prescribed in the Contract, the same shall be reckoned exclusively of the first and inclusively of the last day, except for a payment obligation, in which case, in the event the last day does not fall on a business day, then the last day shall be the next succeeding business day.

(n) The rule of construction, if any, that a contract should be interpreted against the Party responsible for the drafting and preparation thereof, shall not apply.

(o) Reference to any agreement, deed, document, instrument, or the like shall mean a reference to the same as may have been duly amended, modified or replaced. For the avoidance of doubt, it is clarified that a document shall be construed as amended, modified or replaced only if such amendment, modification or replacement is executed in compliance with the provisions of such document(s).

(p) The word "cost" shall be deemed to be all-inclusive also including overhead costs and all taxes under Applicable Law whether on or off the Site.

(q) Wherever provision is made for the giving or issue of any notice, consent, approval, certificate or determination by any person, unless otherwise specified such notice, consent, approval, certificate or determination shall be in writing and the words "notify", "certify" or "determine" shall be construed accordingly.

(r) Any reference to any Applicable Law shall include such law/provision as is from time to time modified or re-enacted or consolidated.

(s) Terms defined in the Schedules, Annexure and Appendices unless contradictory shall have the same meaning throughout the Contract.

(t) Review and comment by the Client or its personnel, with respect to any of such documents or other information shall not relieve or release the Contractor from any of its duties, obligations or liabilities provided for under the terms of the Contract.

2. SCOPE OF WORK

2.1. The Contractor shall execute all the Works as set out in **(attached separately as BOQ),** including all activities required or appropriate to design, fabricate, manufacture, procure and deliver all supplies and Materials required for undertaking the Works for the New admin. & Engg. Block. The Contractor shall carry out and complete the Works in entirety which includes, the supply of all equipment, Materials, plant and machinery, tools, transportation, scaffolding, labour and everything else necessary for the proper execution and successful completion of the Works. The Works shall be undertaken and completed in such a manner that the New admin. & Engg. Block is fit for the purposes.

2.2. The Contractor shall be solely responsible for all means, methods, techniques, sequences, procedures and safety measures programmes in connection with execution of Works.

2.3. The Contractor shall be fully responsible and liable for everything and all matters in connection with or arising out of or being a result or consequence of it carrying out or omitting to carry out any part of the Works. The Contractor is bound to carry out any items of Works necessary for the completion of the New admin. & Engg. Block even though such items of work may not be expressly described in the Bidding Documents.

2.4. The Contractor shall execute the Works consistent with the requirements set forth in the Contract. The Contractor agrees to execute the Works and do all other things required/considered prudent to so do, in relation thereto, in accordance with the parameters set forth in this Clause 2. The Contractor shall be solely responsible for all means, methods, techniques, sequences, procedures and safety programmes in connection with the undertaking the Works under the provisions of the Contract. Without limiting the generality of the foregoing, the Contractor shall execute the Works:

(a) in a continuous manner;

(b) in a proper workmanlike and careful manner and in its entirety, in compliance with Applicable Law and the Codes and Standards, by using methods and Contractor's Equipment which are acceptable as per Prudent Industry Practice;

(c) with safety, dependability, efficiency and economy, in each case, using qualified, competent and where necessary, licensed Contractor's Personnel, so as to successfully achieve the Performance Parameters;

(d) by ensuring that all Works are performed in accordance with the design and instructions provided by the Client;

(e) in accordance with the Quality Assurance Programme; and

(f) with properly equipped facilities and non-Hazardous Materials, except as otherwise specified in the Contract.

2.5. The Contractor shall also execute all such Works and/or supply all such items and Materials that:

(a) can be reasonably inferred from the Contract as being required for attaining Final Completion and Take Over, and which are/is needed for the safe, trouble free and normal operation;

(b) can be reasonably inferred in accordance with Prudent Industry Practice, that the provision or causing the provision of such Works and/or supply of such items and materials, was contemplated as part of the Contract;

(c) is/are necessary to enable the Contractor to fulfill its obligations under the Contract and comply with the warranties set out in the Contract;

(d) is/are necessary to satisfy the provisions of the Technical Specifications; or

(e) although not stated in the Contract, are necessary for stability or for the completion, or safe and proper operation, of the Works;

in each case, as if such Works and/or Materials were expressly mentioned in the Contract and the same shall be considered a part of the Works and shall be executed/supplied by the Contractor, without any additional cost to the Client.

2.6. In the absence of any standard specification in relation to any part of the Works, the Parties shall discuss and mutually agree upon such technical matters pertaining to the Works. In the event the Parties cannot reach a mutual agreement within a period of [15 (fifteen)] days from the date of commencement of such discussions, then the instructions/directions of the Client or Project Manager regarding such technical matters shall be carried out by the Contractor under the Contract.

2.7. Except as otherwise expressly provided in the Contract, the Contractor agrees and acknowledges that it shall perform all its obligations and responsibilities under the Contract, at its own risk, cost and expense.

2.8. As part of the scope of obligations under the Contract, the Contractor shall procure and pay for, in its own name, as an independent contractor and not as an agent of the Client, all items, materials and services necessary in connection with the execution of the Works and all other obligations under the Contract.

2.9. The Client reserves the right to increase or decrease the scope of the Works on any or all items or to change the nature of the Works involved in any or all items or to completely delete any item(s) of the Works under the Contract. The Contractor shall not be entitled to claim for loss of anticipated profits, for mobilization of additional resources, or for any other such reason on account of such instructions. In the event that the Client elects in writing to add an item to scope of the Works or to delete an item from its scope, the Client shall be entitled to increase/reduce (as the case may be) an appropriate amount from the Contract Price.

3. CONTRACTOR'S PERFORMANCE BANK GUARANTEE

3.1. The Contractor shall, at its cost, within [15 (fifteen)] days from the issuance of the Letter of Award and on or before the execution of the Contract Agreement, submit to the Client an unconditional and irrevocable bank guarantee from a reputable bank acceptable to the Client for an amount of INR [__] amounting to 5% (five percent) of the Contract Price in the form as set out in **Schedule I** ("**Performance Bank Guarantee**"). The Performance Bank Guarantee shall be valid up to the expiry of the Defect Liability Period and shall have a claim period of 3 (three) months from the date of its expiry.

3.2. If requested by the Client, the Contractor undertakes to extend the validity period of the Performance Bank Guarantee or to issue a further Performance Bank Guarantee in the event that the duration of the Contract is for any reason extended beyond such validity date.

3.3. Notwithstanding anything contained to the contrary in the Contract and/or the Bidding Documents, no payments due to the Contractor from the Client under the Contract shall be payable by the Client to the Contractor until the Performance Bank Guarantee has been delivered to and approved by the Client.

3.4. Without prejudice to the rights to the Client under Applicable Law or otherwise, the Contractor acknowledges and agrees that the Client shall have the right to invoke the Performance Bank Guarantee in the event of:

(a) failure of the Contractor to commence and/or complete the Works to the Client's satisfaction within the time period specified in Clause 7;

(b) any breach of the Contract by the Contractor which breach has not been remedied within 30 (thirty) days of notice from the Client; or

(c) to recover any amount that may become due to the Client from the Contractor.

4. **ELECTRICAL AND ELV Works OF THE NEW ADMIN. & ENGG. BLOCK**

4.1. **Setting Out**

(a) The Contractor shall execute all Works in relation to the ELECTRICAL AND ELV works of the New admin. & Engg. Block in accordance with the requirements of the Technical Specifications and to the satisfaction of the Client and the Project Manager. The Contractor shall set-out the Works in accordance with the procedures set out under the Technical Specifications or provided to it by the Client and/or the Project Manager.

(b) The Contractor shall be responsible for undertaking the Works. If, at any time during the ELECTRICAL AND ELV works of the New admin. & Engg. Block, the Contractor becomes aware of any error, the Contractor shall promptly and in any event, no later than 15 (fifteen) days from the detection of such error, notify the Client and thereafter at its own expense, immediately rectify such error, to the reasonable satisfaction of the Client.

(c) The Contractor shall be responsible for the true and proper setting out of the Works in relation to instructions given by the Client/Project Manager/Architect in writing and for the correctness, subject as above mentioned, of ELECTRICAL AND ELV Works and for the provision of all necessary instruments, appliances and labour in connection therewith. If, at all any error shall appear or arise in the Works of any part of the Works, the Contractor, on being required to do so by the Client and/or the Project Manager, shall, at its own cost, rectify such error to the satisfaction of the Client. The checking of any defect in the Works by the Client/Project Manager/Architect shall not in any way relieve the Contractor of its responsibility for the correctness thereof and the Contractor shall carefully protect and preserve all bench marks, sight-rails, pegs and other things used in the Works.

4.2. **Contractor's Supervision**

The Contractor shall, during the ELECTRICAL AND ELV Works of the New admin. & Engg. Block, provide all necessary superintendence and ensure that the appropriate Contractor's Personnel are at all times present at the Site, to provide such full-time superintendence. In relation to the supervision during the

Works to be undertaken at the Site, the Contractor shall deploy only such Contractor's Personnel at the Site, who are skilled and experienced in their respective fields and supervisory staff who are competent to adequately supervise the said Works.

4.3. **Inspection**

(a) The Contractor shall provide to the Client and the Project Manager, access to any place on the Site where the New admin. & Engg. Block is being developed, in order to inspect the progress of the Works.

(b) The Contractor shall give the Client and the Project Manager's personnel full opportunity to carry out the activities set forth in this Clause 4.3, including providing access, facilities, permissions and safety equipment. Provided that, no such activity shall relieve the Contractor from any obligation or responsibility under the Contract.

5. CONTRACTOR'S OBLIGATIONS

5.1. **Contractor's general responsibilities**

(a) The Contractor shall execute the Works in accordance with the terms of the Contract, Applicable Law and Prudent Industry Practices. The Contractor shall be liable and responsible for provision of labour and materials for undertaking the Works required to for the New admin. & Engg. Block in accordance with the Contract.

(b) The Contractor shall take full responsibility for the adequacy, stability and safety of all the Works on the Site.

(c) The Contractor shall keep the Client informed of the progress of the Works at regular intervals as required by the Client.

(d) The Contractor shall keep the Client informed of any and all requirements and claims under any Applicable Laws and keep informed the Client of compliance thereunder.

(e) The Contractor shall be responsible for obtaining all information required for the performance of its obligations under the Contract.

(f) The Contractor has clarified and carefully examined all the documents, information and such other matters as may be necessary or desirable for performing its obligations under the Contract, to its entire satisfaction. The Contractor shall not, except as expressly provided in the Contract, be entitled to any extension of time or to any adjustment of the Contract Price, on grounds of misinterpretation or misunderstanding of any such matter.

(g) The Client shall not be responsible for any error, inaccuracy or omission of any kind in the Bidding Documents and shall not be deemed to have given any representation of accuracy or completeness of any data or information. Any data or information received by the Contractor, from the Client and/or Project Manager or otherwise, shall not relieve the Contractor from its responsibility for undertaking the Works.

(h) The Contractor has, prior to the execution of the Contract obtained all information and taken into consideration the restrictions imposed to coordinate its activities for the Works with the other contractors required for completion of the Project.

(i) The Contractor represents that it is fully informed of all general and local conditions near the Site and other factors that may have an effect on the compliance of its obligations under the Contract. The Contractor cannot claim an extension of time or an increase in the Contract Price as a result of such local conditions or factors.

(j) The Contractor represents and confirms that it has entered into the Contract Agreement on the basis of its proper examination of the Site by its checking or carrying out its own investigations as may be required, including the suitability and availability of the access routes thereto and that it is aware about the conditions of the Site and its surroundings and has satisfied itself as to all technical, commercial, social and general conditions of and all circumstances affecting the Site. The Contractor represents and confirms that by signing the Contract, the Contractor accepts total responsibility for having foreseen all difficulties and costs of successfully completing the Works and that the effect of all contingencies have been considered by the Contractor prior to entering into the Contract Agreement and that the Contractor shall not be entitled to extension of time or an increase in the Contract Price on account of the same.

(k) The Contractor acknowledges that any failure to verify and interpret any data and information in relation to the Site and/or the New admin. & Engg. Block shall not relieve it of its responsibility for properly estimating the difficulty or cost of successfully performing its obligations under the Contract.

5.2. **Water and power for carrying out the Works**

Water and electricity for carrying out the Works shall be arranged by the Contractor at its own risk and costs. The Contractor shall, so far as is reasonably practicable, having regard to local conditions provide on the Site at its own cost, water for the use of the Contractor's Personnel, staff, and work people at the Site.

5.3. **Temporary works and arrangements**

The Contractor shall furnish to the Client full particulars, Drawings, etc., of all temporary works necessary for the completion of the Works and shall allow sufficient time for the Client to consider the same. The Client reserves the right to alter/ comment on the Contractor's proposals if it considers that modifications should be made. The Contractor shall be solely responsible for the stability and safety of all temporary Works and unfinished Works.

5.4. **Demolition and clearance**

The Contractor shall be responsible for undertaking the Works, clearance from the Site of all scrub, debris, rubbish, etc. that shall be carted to an area not objected to by any Governmental Authorities. However, no trees shall be removed without the prior permission of the Client and without obtaining prior approvals as may be required under the Applicable Law.

5.5. **Storage, cleaning and de-watering**

(a) The Contractor shall at all the times during performance of the Works keep the Site clean and free from all debris and unwanted Materials as per instructions of the Client/ PM.

(b) Storage of Materials shall be in organized manner and in proper compartments. Storage on suspended floors shall not be permitted unless specifically approved in writing by the Client for specific Materials in specific locations. The Client shall be furnished with load details, if requested, before seeking approval for storage.

(c) Regular cleaning operations shall be undertaken to remove all dust, debris, waste materials, etc. and disposal of the same. A cleaning schedule shall be maintained by the Contractor to the satisfaction of the Client.

(d) The Contractor shall make its own arrangements for storage of Materials, which cannot be accommodated at the Site. The Contractor shall be fully responsible for safe custody of the same. Materials shall be considered as "Delivered at Site", only after the physical presence of Materials at the Site. Stores elsewhere shall not be eligible for being considered as "Delivered at Site".

(e) The Contractor understands that the Site is free from pollutants at the time of access to the Site and commencement of Works. The Contractor shall comply with all applicable environmental laws and regulations and shall ensure that the Works are undertaken in compliance with such Applicable Laws.

(f) The Contractor shall be responsible to keep entire Site free from water due to water coming from any source at any level and shall protect all Materials and Works from being damaged by the water from any source. The Contractor shall make proper arrangements for drainage prior to use of water.

5.6. **Vehicular movements and temporary roads**

(a) The Contractor shall not make temporary roads until approval from the Client is received in writing. Site access and circulation roads are to be on the lines agreed to with the Client.

(b) No vehicle other than those specifically allowed by the Client shall be permitted on the Site.

(c) All the vehicles and Materials coming in to the Site should be checked for explosive materials by using metal detectors and under vehicle scanner.

5.7. **Care and use of existing facilities and services**

(a) During the completion of the Works, the Contractor shall take all precautions and exercise full care, at its cost, to ensure that no damage is caused to the existing water supply, sewerage, power or telecommunication lines or any other services or works. The Contractor shall provide and erect before undertaking the Works, substantial barricades, guardrails, and warning signs. The Contractor shall furnish, place and maintain adequate warning lights, signals, etc., as required by Client. However, such substantial barricades, guardrails, and warning signs shall not relieve the Contractor of its responsibilities, obligations and liabilities for safety and timely completion of Works.

(b) If any service lines have to be shifted / diverted, it shall be done so with the explicit permission of the Client.

5.8. **Co-ordination of builders work required for services**

(a) The Contractor shall co-ordinate the requirements for holes, fixings and builders work, for internal and external services installations in accordance with the requirements of the relevant Drawings, which shall be made available to the Contractor by the Client.

(b) All holes, chases, etc., shall be left in the building work as it proceeds and cut-out subsequently, except in so far as may be necessary due to subsequent authorized instructions. The Contractor shall therefore obtain necessary builders work details in such order and in such time so as to enable them to be checked and approved by the Client and/or the Project Manager not less than 2 (two) weeks before the actual works are planned to take place.

5.9. **Contract**

The Contractor shall within [__] days of the issuance of the Letter of Award enter into and execute the Contract Agreement with the Client, in the form annexed as **Schedule II** with such modification as may be necessary. The cost of stamp duties and similar charges (if any) incurred with respect to entry into the Contract Agreement shall be borne by the Contractor.

5.10. **Inspection of Site**

(a) The Contractor shall be deemed to have inspected and examined the Site and its surroundings and information available in connection therewith and to have satisfied itself as to the form and nature of the Works. The Contractor shall not rely only on the information provided by the Client.

(b) The Contractor shall not remove/shift any existing services passing through the Site above or below ground deemed to be a hindrance towards the completion of the Works without the prior written consent of the Client.

5.11. **Works to be to the satisfaction of the Client**

Unless it is legally or physically impossible, the Contractor shall undertake the Works in strict accordance with the Contract to the satisfaction of the Client and shall comply with and adhere strictly to the instructions and directions from the Client and/or the Project Manager.

5.12. **Drawings and Documents**

(a) **General**

The Drawings and Documents prepared for the Project shall be treated as confidential documents and must not be copied or loaned or shared with any other party without the express permission of the Client. In the event of termination of the Contract, the Contractor shall forthwith return to the Client, all Drawings and Documents prepared for the Project and all copies thereof in the possession or under the control of the Contractor. The Contractor agrees that the provisions of the Contract pertaining to confidentiality shall survive termination/completion of the Works under the Contract.

(b) **Drawings**

(i) The Drawings furnished by the Architect, if any, as part of the Bidding Documents, are for bidding purposes only and are intended as a guide to the Contractor and give general layout of buildings and structures and general positions of utilities, services and equipment only and in measuring from these Drawings and preparing Bid the Contractor must make due and proper allowance for all necessary diversions from the straight line, rises or falls as may be required for the proper execution of the Works.

(ii) The set of Drawings which are part of the Bidding Documents is only representative of the type and general nature of Works and not the quantum of Works involved. Additional Drawings shall be issued at the relevant stage for actual execution of Works.

(iii) Detail Drawings in all cases shall be worked in preference to those of a more general nature and figured dimensions where indicated shall be followed in preference to scaled dimensions.

(c) **Good for Construction Drawings**

(i) The Architect/Client/or the Project Manager shall issue free of charge [3 (three) sets] of ELECTRICAL AND ELV Drawings, approved for undertaking the Works, to the Contractor. Additional copies as and when required shall be supplied by the Architect or Project Manager and costs shall be reimbursed by the Contractor.

(ii) The Client and/or Project Manager may from time to time during the course of the Contract issue the Contractor with revised Drawings and the Contractor shall ensure that all superseded Drawings are removed from Site and stored in a lockable cabinet as directed by the Client and/or Project Manager and replaced by revised Drawings.

(iii) The Contractor shall ensure that a complete up to date register of Drawings is maintained at Site. All Drawings shall be properly filed and indexed for ready reference.

(iv) The Contractor shall ensure that only the valid up to date Drawings is used for fabrication, setting-out, ELECTRICAL AND ELV etc.

5.13. **Discrepancies**

The Contractor shall bring to the notice of the Client any discrepancies within or between Drawings and/or the other Documents prior to commencement of Works and shall not proceed with Works until the Client/Architect/PM gives clarifications and instructions to proceed.

5.14. **As-built drawings**

The Contractor shall commence preparation of the 'as-built drawings' from the onset of the Contract, in order that all minor amendments and discrepancies are incorporated. To ensure that this requirement is complied with, the Client shall check the Drawings on its request as the Works proceed. [4 (four)] sets of as-built drawings and one soft copy on a CD shall be submitted by the Contractor to the Client within 2 (two) weeks from date of issue of the Final Acceptance Certificate.

5.15. **Programme**

(a) The Contractor shall include in its Bid a preliminary contract schedule. Upon issuance of the Letter of Award and before commencement of the Works, the Contractor shall prepare a detailed and comprehensive contract schedule for review and approval by Client/PM.

(b) The schedule shall show the date on which each part of the Works is to begin and date when such part of the Works is scheduled to be finished along with the relevant milestones under ("**Contract Schedule**"). The Contractor shall ensure that it complies with the Contract Schedule and shall co-ordinate performance of the Works with the Client, Project Manager and the Architect in order to maintain the Contract Schedule.

(c) The Contractor shall also submit weekly/monthly progress reports indicating progress of Works giving scheduled and actual percentage completion, causes for delays if any etc. as well as other reasonable reports and photographs as the Client and/or Project Manager may require from time to time.

(d) The submission to and approval by the Client and/or Project Manager of such schedules or the furnishing of such particulars shall not relieve the Contractor of any of its duties or responsibilities under the Contract.

(e) The Contractor acknowledges and confirms that the development of the New admin. & Engg. Block is a time bound project. The Contractor shall strictly adhere to the milestones as per the

Contract Schedule. Any delay in delivering the Project, completing the Works and meeting the milestones will result in substantial losses to the Client.

(f) Subject to Clause 10 (Liquidated Damages) for any delays by the Contractor in achieving the any milestone as per the Contract Schedule, the Client will withhold an amount from the Invoice maximum up to 5% (Five percent) of the Contract Price until the Contractor meets the subsequent milestone as per the Contract Schedule. On successfully achieving the subsequent milestone, the withheld amount will be paid to the Contractor in the next Invoice. If the Contractor fails to achieve the subsequent milestone, an additional 5% (five per cent) of Contract Price shall be withheld. The entire withheld amount shall be accounted in the Contract Price.

(g) The Contractor will submit schedule of Material delivery and shall obtain approval from the Client/PM before delivering any Material to the Site.

(h) Provision of time will be made by the Contractor for other agencies and contractors to carry out their part of the Works and such lapse of time will be considered by the Contractor in the Contract Schedule. No compensation will be paid to the Contractor for idle labour and Materials due to work of other contractors.

5.16. **Contractor's Representative and Works Manager**

Contractor's Representative

(a) The Contractor has appointed [__], s/o [__] and r/o [__], as the Contractor's representative for the purpose of the Contract ("**Contractor's Representative**"). The Contractor shall within [7 (seven) days] from the date of issuance of Letter of Award, notify the Client, of the duties and authorities of the Contractor's Representative.

(b) The Contractor's Representative shall represent and act for the Contractor, at all times during the term of the Contract and shall provide to the Client all the Contractor's notices, instructions, information and all other communications under the Contract.

(c) All notices, instructions, information and all other communications provided by the Client to the Contractor under the Contract, shall be provided to the Contractor's Representative or, in its absence, its authorized deputy, except as otherwise provided.

(d) The Contractor shall not revoke the appointment of the Contractor's Representative without the Client's prior written consent, which shall not be unreasonably withheld. If the Contractor proposes to appoint another person as its representative, then it shall provide a [14 (fourteen) days] notice to the Client requesting it to approve such appointment. In this regard, the Contractor shall submit the curriculum vitae of such representative along with its request. The Contractor shall ensure that the person proposed to act as its representative shall be fluent in the local language of India and the English language. If the Client does not object to the appointment of such representative within [14 (fourteen) days] of receipt of the request provided by the Client, the representative shall be deemed to have been approved by the Client as the Contractor's Representative. If the Client objects to the appointment of the representative within [14 (fourteen) days] of receipt of the request provided by the Contractor, giving the reason thereof, then the Contractor shall propose a replacement within 14 (fourteen) days of such objection. The provisions of this Clause 5.23(d) shall apply *mutatis mutandis* to such replacement. If the Client consents thereto, the Contractor shall appoint any other person as the Contractor's Representative, pursuant to the procedure set out in this Clause 5.23.(d).

(e) The Contractor's Representative may, subject to the approval of the Client, which shall not be unreasonably withheld, at any time, delegate to any person any of the powers, functions and authorities vested in it. Any such delegation may be revoked by the Contractor's Representative at any time, but shall be subject to a prior notice to the Client, signed by the Contractor's Representative. Such notice shall specify the powers, functions and authorities thereby revoked. No such delegation or revocation shall take effect unless a copy of written authorization of such delegation or revocation, as the case may be, has been delivered to the Client.

(f) Any act or exercise by any person of powers, functions and authorities so delegated to such person in accordance with Clause 5.23(e) shall be deemed to be an act or exercise by the Contractor's Representative and the Contractor shall be fully responsible for the same.

(g) The Contractor's Representative, persons to whom powers, functions and authorities have been delegated pursuant to Clause 5.23(e), and the Works manager shall be fluent in the English language and either proficient in the national language of India.

(h) **Works Manager**

The Contractor's Representative shall, [7 (seven) days] before Site mobilization, appoint a suitable person to manage the execution of the Works, who shall be present at the Site, during normal working hours prescribed under Applicable Law ("**Works Manager**"). Provided that, if at any point of time the Works Manager is not present at the Site, a suitable person shall be appointed by the Contractor's Representative to act as its deputy, who shall then be present at the Site in the absence of the Works Manager.

(i) **Removal of Contractor's Personnel from Site**

The Contractor's Personnel shall be reasonably qualified, skilled and experienced in their respective trades or occupations. The Client may, during the term of the Contract, by notice to the Contractor, object to the retention of any of the Contractor's Personnel and require the Contractor to remove (or cause to be removed) any person comprising the Contractor's Personnel, who,

(i) has behaved inappropriately;

(ii) carries out duties incompetently or negligently;

(iii) persists in any misconduct or lack of care;

(iv) fails to conform with any of the provisions of the Contract;

(v) has committed a serious breach of the Site regulations provided by the Client;

(vi) persists in any conduct which is prejudicial to the safety, health or the protection of the environment; or

(vii) is otherwise not suitable.

The Client shall provide evidence of the same to the Contractor, whereupon the Contractor shall remove such person from the Site and promptly appoint (or cause to be appointed) a suitable replacement in accordance with Clause 5.23(d).

5.17. **Contractor's Employees**

The Contractor shall provide and employ on the Site in connection with the execution of the Works:

(a) only such technical assistants as are skilled and experienced in their respective fields and such sub-agents, foremen and leading hands as are competent to give proper supervision to the Works they are required to supervise;

(b) such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Works; and

(c) professionals for safety for undertaking the Works to the satisfaction of the Client.

5.18. **Watching and Lighting**

The Contractor shall in connection with the Works provide and maintain at its own cost all workplace lighting, guards, fencing and watching when and where necessary for the completion of the Works, or for the safety and convenience of the public or others. The care and the safety of the Materials and Works shall be sole responsibility of the Contractor. The constructed barricade on the Site shall be maintained by the Contractor. If such barricade is damaged, the same shall be replaced/rectified immediately without any additional cost to the Client. Adequate fire protection measures should be in place on site to attend to any mishap on the site. Adequate personnel shall be deployed by the Contractor within the Site to control the movement of Material and personnel.

5.19. **Care of Works**

From the commencement of the Works until the date stated in the Final Acceptance Certificate, the Contractor shall take full responsibility for the care of the Works and the loss or damage thereto.

5.20. **Damage to persons and property**

The Contractor shall indemnify the Client against any and all losses and claims in respect of injuries or damage to any persons or material or physical damage to any property whatsoever which may arise out of or in consequence of the execution of the Works and against all claims, proceedings, damages, costs, charges and expenses whatsoever in respect of or in relation thereto.

5.21. **Giving of notices and payment of fees**

The Contractor shall give all notices and pay all taxes, octroi, fees required to be given or paid by any national or state statute, ordinance or other Applicable Law, or any regulation, or bye law or any local or other duly constituted Governmental Authority in relation to the execution and completion of the Works and by the rules and regulations of all public bodies and companies whose property or rights are affected or may be affected in any way by the Works.

5.22. **Compliance with statutes, regulations, etc.**

(a) The Contractor shall conform in all respects with the provisions of Applicable Law which may be applicable to the Works and shall keep the Client indemnified against all penalties and liability of every kind for breach of any such Applicable Law.

(b) The Contractor shall comply with all rules, regulations, and laws including but not limited to labour laws, laws relating to medical and safety of workmen for labour directly or indirectly engaged by the Contractor, its representative, and Sub-Contractor. The Contractor shall register itself

wherever and whomsoever required in this connection at local and state level. The Contractor shall indemnify the Client from every expense incurred by the Client under this Clause. The Client is authorized to call at any point of time to its registered office/offices for inspection or copy of such documents as it considers necessary for ensuring statutory compliances to the above by the Contractor.

(c) In particular, the Contractor shall ensure strict compliance with the provisions of the Employee State Insurance Act, 1948, Employee Provident Fund and Miscellaneous Provisions Act, 1952, Factories Act, 1948, Workman's Compensation Act, 1948, Payment of Wages Act, 1946, Minimum Wages Act, 1948, Employees Liability Act, 1938, Industrial Dispute Act, 1947, Maternity Benefit Act, 1961, and Contract Labour (Regulation and Abolition) Act, 1970. Copies of the records and registers maintained under the Applicable Laws shall be provided to the Client at the end of each month. The salaries to all workmen shall be paid in the presence of the Client and/or Project Manager. The Contractor shall procure and maintain the necessary licenses under the Contract Labour (Regulation and Abolition) Act, 1970 after assisting the Client in procuring the registration there under. The Contractor shall also obtain various licenses/ permits/ clearance/ approvals/ consents as appropriate from the various Governmental Authorities and other statutory authorities in respect of Works to be undertaken by it.

(d) The Contractor shall ensure that the workmen operating the Contractor's Equipment for the execution of Works are licensed under Applicable Law, to the satisfaction of the Client.

(e) The Contractor shall include in its rates all expenses necessary to meet its obligations for making contributions toward employee benefits funds (such as employees state insurance, provident fund, old age pension if any or any other benefits / compensation payable by the Contractor) etc., in compliance with all the statutory regulations and requirements. All records in this connection shall be properly maintained by the Contractor and produced for scrutiny by the concerned authorities and the Client and/or Project Manager whenever called for.

(f) The Contractor acknowledges and agrees that none of the directors of the Contractor are on the RBI's defaulter list/caution list or the CIBIL's wilful defaulter list or is a defaulter or on non-cooperative list of any of the lenders and that no director of the Contractor is disqualified under Section 164 of the Companies Act, 2013. The Contractor further agrees and acknowledges that no person:

(i) who has been named in any list of defaulters circulated by the RBI or CIBIL; or

(ii) whose name appears in any caution list of any nature published by the RBI, CIBIL or any similar Governmental Authority; or

(iii) who has been named in the caution list/defaulters list/ specific approval list; or

(iv) who has been identified as a wilful defaulter/ non-cooperative by any bank or financial institution, as per the parameters determined by RBI, from time to time; or

(v) who is director in any company which has been identified as a wilful defaulter/defaulter / non-cooperative by the RBI, CIBIL or similar Governmental Authority or any bank or financial institution,

shall become a member of the Board or a KMP of the Contractor. If any such person is already a director on the Board or KMP of the Contractor, the Contractor shall intimate the Client and the Project Manager promptly and take expeditious and effective steps to remove such person from

its Board and as KMP, and the Client shall have the right to take action as envisaged under the Applicable Law.

(g) The Contractor acknowledges and agrees that no investigation by a Governmental Authority or any regulatory authority is pending against the Contractor, its sister concern, its chief executive officer or any of its directors/ managers/ employees, including but not limited to any charge sheet by an agency of the Governmental Authority, initiation of proceedings in the court of law or a conviction by the court of law for an offence committed by the Contractor or its sister concern or any of its directors/ managers/ employees. In case any investigation is pending against the Contractor or its sister concern or against its chief executive officer or any of its directors/ manager/ employees, the following details shall be furnished to the satisfaction of the Client:

(i) full details of such investigation;

(ii) name of the investigating agency;

(iii) charge/ office for which investigation has been launched;

(iv) name and designation of persons against whom the investigation has been launched;

(v) other relevant information.

(h) The Contractor shall keep the Client informed of any and all claims under any Applicable Laws and keep informed the Client of compliance there under.

5.23. **Interference with traffic and adjoining properties**

All operations necessary for the completion of the Works shall, so far as compliance with the requirements of the Contract permits, be carried on so as not to interfere unnecessarily or improperly with the public convenience, or the access to use and occupation of public or private roads and footpaths, or to or of properties whether in the possession of the Client or of any other person. The Contractor shall save harmless and indemnify the Client in respect of all claims, proceedings, damages, cost, charges and expenses whatsoever arising out of, or in relation to, any such matters in so far as the Contractor is responsible therefore.

5.24. **Extraordinary traffic**

The Contractor shall use every reasonable means to prevent any of the highways or bridges communicating with or on the routes to the Site from being damaged or injured by any traffic of the Contractor or any of its Sub-Contractors and, in particular, shall select routes, choose and use vehicles and restrict and distribute loads so that any such extraordinary traffic as will inevitably arise from the moving of material from and to the Site shall be limited, as far as reasonably, and so that no unnecessary damage or injury may be occasioned to such highways and bridges.

5.25. **Opportunities for other contractors**

The Contractor shall, in accordance afford all reasonable opportunities for carrying out the Works to any other contractors engaged by the Client and their workmen and to the workmen of the Client and of any other duly constituted authorities who may be employed in the execution on or near the Site of any Works not included in the Contract or of any contract which the Client may enter into in connection with or ancillary to the Works.

5.26. **Contractor to keep Site clear**

During the progress of the Works, the Contractor shall keep the Site free from unnecessary obstruction and shall store or dispose of any material and clear away and remove from the Site any wreckage, rubbish or Materials no longer required, on a daily basis. Regular cleaning operations on daily basis shall be undertaken by the Contractor to remove all dust, debris, waste materials etc., and disposal of the same to the nearby waste dumping yard. If Client and/or Project Manager notices the Contractor's inability/unwillingness to do the said job, the Client shall have the right to get the same cleaned by an external agency and debit the same to the Contractor's account.

5.27. **Clearance of Site on completion**

On the completion of the Works, the Contractor shall clear away and remove from the Site all surplus Materials, rubbish and debris and Site office and stores etc. of every kind, and leave the whole of the Site and Works clean and in a workmanlike condition to the satisfaction of the Client.

5.28. **Contractor's Personnel**

(a) The Contractor shall within 7 days from the date of issuance of Letter of Award depute the Contractor's Personnel, at the Site so as to seek clarification with regard to the Works to be executed. Further, subject to details as provided in the Technical Specifications, the Contractor shall, in terms of this Clause 5.36, from the date of Letter of Award till Final Completion, engage sufficient and properly qualified Contractor's Personnel who are proficient in English language and skilled and experienced in their respective callings, to enable the Contractor to efficiently perform its obligations under the Contract. The Contractor shall ensure that the Contractor's Personnel include:

(i) professional engineers licensed in accordance with the licensing requirements prescribed under Applicable Law to perform the Works pursuant to the Contract;

(ii) a team of engineers from various disciplines, adequate number of qualified and competent supervisory staff, craftsmen or other personnel, each of whom shall have extensive experience in executing works of a magnitude similar to the Works, shall have knowledge of the Applicable Laws; and

(iii) a team of sufficiently qualified and experienced welders which are required for the execution of the Works.

(b) The Client shall have the right, but not the obligation, to approve any of the Contractor's Personnel. The Contractor shall, upon the request of the Client, provide the Client with the curriculum vitae of, and arrange interviews by the Client of, any or all of the Contractors Personnel. The Contractor shall not remove any of the Contractor's Personnel without the prior written consent of the Client, which shall not be unreasonably withheld.

(c) The Contractor shall not permit any of the Contractor's Personnel to maintain any temporary or permanent living quarters within the structures forming part of the Site. The Contractor shall be responsible for the recruitment, transportation, accommodation, catering and other welfare facilities of the Contractor's Personnel, and for all payments in connection therewith. Further, if specified in the Technical Specifications, the Contractor shall also provide all such facilities for the Client's personnel. The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor's Personnel. In collaboration with the relevant

Governmental Authorities, the Contractor shall ensure that medical staff, first aid facilities, sick bay and ambulance services are available, at all times, at the Site and at the respective accommodation of the Contractor's Personnel, and that suitable arrangements are made for all necessary welfare and hygiene requirements and for the prevention of epidemics. The Contractor shall indemnify and hold harmless the Client from and against any claim, liability, assessment, damage, loss, penalty or fine stemming from any breach by the Contractor or any person for whom it is responsible, of this Clause 5.36.(c).

(d) The Contractor shall, within [15 (fifteen) days] from the date of issuance of Letter of Award, appoint suitable and qualified persons, who shall be:

(i) responsible to ensure quality of the Works undertaken for construction and development of the New admin. & Engg. Block and shall co-ordinate with the Client and the Project Manager for all matters in relation to the quality of the Works (the "**Quality Engineer**");

(ii) responsible for all matters in relation to the safety and protection against accidents at the Site and shall, at all times during the term of the Contract, ensure that the safety manual provided to the Contractor by the Client and the safety regulations at the Site provided under **Schedule VII** (Safety Regulations) are strictly adhered to (the "**Safety Officer**"). The Contractor shall, no later than [15 (fifteen) days] from the date of issuance of the Letter of Award, submit to the Client, the job safety analysis of the Safety Officer. The Safety Officer shall have the authority to issue instructions and take protective measures to prevent accidents and during the term of the Contract, the Contractor shall provide whatever is required by the Safety Officer to exercise such responsibility and authority. The Safety Officer shall:

(A) ensure that copies of the safety manuals provided by the Client pursuant to **Schedule VII**, are at all times available on the Site, along with Codes and Standards of practice in relation to the same, to be referred to and followed by the Contractor's Personnel;

(B) submit to the Client, as soon as practicable after the occurrence of an accident or dangerous occurrence, the details of such accident or dangerous occurrence, as the case may be; and

(C) maintain all records and make reports concerning health, safety and welfare of persons, and damage to property, as may be reasonably required by the Client.

The Contractor shall indemnify and hold harmless the Client from and against any claim, liability, assessment, damage, loss, penalty or fine stemming from any breach by the Contractor or any person for whom it is responsible, of this Clause 5.36.(d).

(e) The Safety Officer shall be present at the Site, during normal working hours, prescribed under Applicable Law, or a suitable person shall be appointed by the Contractor's Representative to act as its respective deputy, who shall be present at the Site in the absence of the Safety Officer.

(f) The Contractor shall, at its own expense, provide, as and when required, the means of repatriation to all of the Contractor's Personnel and labour and personnel of the Sub-Contractor's to their respective home countries/states. Further, the Contractor shall also provide suitable temporary maintenance of all such persons, from the period commencing from the cessation of their employment with the Contractor, till the scheduled date of their respective departures. If the

Contractor fails to comply with its obligations under this Clause 5.36.(f), the Client may provide the same, at the cost of the Contractor.

(g) The Contractor shall ascertain the availability of labour (skilled and unskilled), personnel and Sub-contractors in the vicinity in which the Site is located and shall, to the extent possible, engage such labour (skilled and unskilled), personnel and Sub-contractors, as the Contractor's Personnel.

(h) The Contractor shall ensure that the Contractor's Personnel are entitled to the prescribed number of holidays, as per Applicable Law and unless otherwise provided in the Contract, no Works shall be executed outside normal working hours and on holidays, prescribed under Applicable Law. Provided that, provisions of this Clause 5.36.(h) shall not apply to any Works which are customarily carried out by rotating or double-shifts.

(i) The Contractor shall, and shall ensure that the Contractor's Personnel, in all dealings with the labor and personnel of its Sub-Contractors, pay due regard to all recognized festivals, official holidays, religious or other customs prevailing in the State of Uttar Pradesh, India and all Applicable Laws in this regard. Further, the Contractor shall ensure that the Contractor's Personnel act in a culturally sensitive manner at all times, giving due regard to the local community and cultures when on Site.

(j) The Contractor shall at all times, during the term of the Contract, use its reasonable endeavors to prevent any unlawful, riotous or disorderly conduct or behavior by or amongst the Contractor's Personnel, the other Contractors and/or the labour, personnel and employees of the Sub-Contractors and to preserve peace and protection of persons and property on and near the Site and under no event shall the Client be responsible for the same. The Contractor shall promptly provide the Client, a notice in relation to any actual or anticipated labour dispute which may affect the execution of the Works. The said notice shall indicate the steps being taken by the Contractor to mitigate the effects of any actual or contemplated labour disputes.

(k) The Contractor shall pay rates of wages to the Contractor's Personnel, as per rates prescribed under Applicable Law and observe conditions of labour in accordance with the Applicable Law. The Contractor shall, during the term of the Contract, withhold from wages and salaries of the Contractor's Personnel, sums required to be withheld as per the Applicable Law and pay the same promptly and directly, when due, to the respective Governmental Authority and upon request by the Client, in this regard, provide to the Client evidence of the payment of such withholding taxes as per the Applicable Law. In this regard, the Contractor shall comply with all accounting and reporting requirements under the Applicable Law and bear the cost of such compliance. In the event the Client becomes liable, under Applicable Law, due to any act or omission of the Contractor under this Clause 5.36.(k), the Client may make such payments and shall recover the same from the Contractor or deduct the amounts so paid from the Contract Price.

5.29. **Sanitation and drainage during the Works at the Site and labour camp**

(a) The Contractor shall provide sanitation and drainage facilities on the Site and labour camp as required and stated under the Contract.

(b) The Contractor shall strictly control the labour so that the Site is not polluted, made dirty or littered with debris, wastes or the likes.

(c) Any person found creating mess or litter or pollution or illegally squatting on the Site shall be removed from the Site immediately at Contractor's cost.

(d) The Contractor shall provide sanitation facilities at convenient locations on Site and labour camp to preserve the cleanliness of the Site. The effluent shall be directed as follows:

(i) waste water: Collection and pumping out and disposal off the Site in approved manner: and

(ii) septic tank provision - sludge to be collected and disposed of at intervals as directed.

(e) The Contractor shall clear and deodorize the ground after their removal and meet all statutory requirements.

5.30. **Worker's camp**

The Contractor shall make its own arrangements at its cost to provide accommodation for its staff and labour outside and away from the Site. No extra cost is payable to the Contractor on this account. The Contractor shall provide the following welfare arrangements in the labour camp area within [___] km of the Site and as further detailed in the Technical Specification:

(a) the Site activities include setting up a colony for the workers. Well laid out labour camp with all amenities (light, drinking water, cooking area with cooking facilities, wash areas, wash rooms for both male & female workers, crèche & learning area) shall be arranged at a suitable place;

(b) labour camp shall be located away from Site premises;

(c) access to the labour camp shall be provided;

(d) maintain proper hygiene all times;

(e) a warden to be appointed for labor camp and as single point responsibility;

(f) drainage of sludge water /rain water shall be provided;

(g) drinking water, bathing facilities and field washrooms should be provided at suitable places;

(h) suitable arrangements for labour to purchase weekly provisions shall be made;

(i) weekly off to the labour shall be ensured for rest;

(j) food and transport (to & fro from Site to labour camp) facilities should be provided;

(k) sufficient number of fire extinguishers should be provided;

(l) an emergency assembly point should be provided;

(m) security should be provided;

(n) crèches/learning/play centre should be provided;

(o) provision of pumps to drain out flood water from site/ labour camp;

(p) electricity (with power back up) should be provided;

(q) first aid facility, ambulance & along with doctor shall be provided;

(r) labour camp monsoon precautions;

(s) prevent contamination of drinking water;

(t) collection and disposal of food waste & garbage regularly;

(u) secure all loose [G. I. Sheets] to prevent from flying off in case of stormy and gusty wind;

(v) standard earthing to partition with effective functioning of [ELCB's]

(w) all temporary electric connections must be rooted through 30 mA cut off rating [ELCB];

(x) all wires / cables are not laid on sharp edges or through a hole within the G. I. Sheet as to prevent damage to insulation. If, possible route through conduit pipes and support wire / cables by suitable hook;

(y) no wooden material to be used for labor camp construction; and

(z) all wire / cable joints are water and shock proof to prevent from shock.

5.31. **Alcoholic liquor or drugs**

Use of any alcoholic liquor, drugs, chewing of pan, gutka or smoking etc., is fully prohibited on the site. The Contractor shall not import, sell, give, barter or dispose any alcoholic liquor or drugs or cigarettes / beedies /etc. by its Sub-Contractors, agents or employees.

5.32. **Arms and ammunition**

The Contractor shall not give, barter or otherwise dispose of to any person or persons, any arms or ammunition of any kind or permit or suffer the same as aforesaid.

5.33. **Festivals and religious customs**

The Contractor shall in all dealings with labour in its employment have due regard to all recognized festivals, days of rest and religious or other customs. The Contractor shall intimate [7 (seven) days] in advance to the Client of any festival for any resource/ labour shortfall presumed with proper mitigation plan in place.

5.34. **Epidemics**

In the event of any outbreak of illness of an epidemic nature at Site and/or labour camp for the workmen engaged for the Works (directly or indirectly) the Contractor shall comply with and carry out such regulations, orders and requirements as may be made by the Governmental Authority, or the local medical or sanitary authorities for the purpose of dealing with and overcoming the same under Applicable Law.

5.35. **Disorderly conduct, etc.**

The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by any of its Sub-Contractors, employees or agents and for the preservation of peace and protection of persons and property in the neighborhood of the Works against the same.

5.36. **Safety Standards and Requirements**

The Contractor shall follow the rules and guidelines laid down in safety requirements as listed in **Schedule VII**. The cost so incurred by the Contractor in providing for safety standards and requirements as above shall be deemed to be included in the Contract Price and no extra amounts shall be payable to the Contractor on this account.

5.37. **Reports by the Contractor**

(a) The Contractor shall file daily category-wise labour returns. The report shall indicate scheduled requirement against actual strength.

(b) The Contractor shall prepare weekly reports of planned and actual progress of Works and subsequent week's scheduled Works. These will also include Material procurement status. These reports shall be submitted to Client and shall be reviewed in weekly co-ordination meeting.

(c) The Contractor shall submit monthly report along with monthly bills. The reports shall include photographs taken from pre-determined locations which illustrate progress of the Works.

(d) Further progress charts and schedules shall be prepared by the Contractor as directed by the Client and/or Project Manager.

(e) The submission to and approval by the Client of such programmes/ reports or the furnishing of such particulars shall not relieve the Contractor of any of its responsibilities and liabilities under the Contract.

5.38. **Night or Sunday work**

Subject to Applicable Law and the terms of the Contract, the Contractor shall not perform any activity at the Site at night on any day or on Sundays except with the prior written consent of the Client and the Project Manager.

5.39. **Taxation**

The Contractor shall be responsible to pay personal and company taxes of its staff and its organization wherever applicable. The Contractor shall be responsible for deduction of tax at source while releasing payment to their staff, Sub-Contractors, workers, etc.

5.40. **NGT Guidelines**

The Contractor shall comply with all the provisions of National Green Tribunal (NGT) laws, rules, orders, notifications, and amendments made from time to time at his own cost, nothing extra shall be paid on this account. Any penalty, imposed by the NGT for construction of aforesaid building due to non-compliances shall be borne by the contractor itself. The item rates of BOQ are inclusive of all such cost to manage the activities as suggested by NGT If site shutdown/ work held due to NGT/ Govt. orders then, the Contractor shall only be entitled to Extension of time and no claim shall be entertained on account of this by the owner on account of idle labour, staffs tools & plants, machineries etc.

6. CLIENT'S OBLIGATIONS

6.1. **Rights of Way and Facilities**

(a) The Client shall provide and bear all costs and charges for special and/or temporary rights of way, which the Contractor may require, including those for access to the Site.

(b) The Client shall provide clear, unhindered, freely accessible Site to the Contractor for execution of the Works.

(c) The Client shall, in respect of the Works, provide adequate space for the storing of Contractor's Equipment (including equipment which is being procured by the Client under a separate contract) until the Completion Date.

6.2. **Access to the Site**

The Contractor and Contractor's Personnel shall be permitted access to the Site for the purposes of carrying out the Works. The Client, may at any time, remove or cause to be removed any of the Contractor's Materials, articles, things, personnel or labour without notice to the Contractor. This shall not, in any manner, prejudice or affect the Contractor's liabilities and obligations in respect of the Works and in particular the liability arising due to any damage to any person or Material at the Site.

7. **TIME FOR COMMENCEMENT AND COMPLETION**

7.1. **Commencement of works**

The Contractor shall commence the Works at the Site from the date of issuance of the Letter of Award ("**Commencement Date**"). The Contractor acknowledges that time is the essence of the Contract for commencement and completion of Works by the Completion Date.

7.2. **Time for completion and extension of time**

(a) The Contractor agrees and undertakes to complete the Works in accordance with the terms of the Contract and the Bidding Documents within 6 months from the Commencement Date ("**Completion Date**") subject to Clause 7.2.(b) below.

(b) In the event that the Contractor is delayed in performing the Works under the Contract solely as a result of:

(i) an event of Force Majeure; or

(ii) on account of Change in Law; or

(iii) breach by the Client of its material obligations herein,

then the Contractor shall issue a written notice to the Client and the Project Manager promptly upon occurrence of any of the events specified above indicating the reasons for the delay, the additional time required by the Contractor to complete the Works and the corrective action already undertaken or to be undertaken. The Client upon receipt of notice from the Contractor shall determine the time period for extension and whether such extension shall take place retrospectively or prospectively. Provided that, the Contractor shall be solely responsible for all costs and risks on account of such extension of time.

(c) The Parties agree that any extension of time shall only be considered when work on the critical path of the program for the Works is affected. It shall be the duty of the Contractor at all times to use all reasonable endeavors to prevent any delay being caused by any of the events or

circumstances mentioned in this Clause 7.2, to minimize any such delay as may be caused thereby, and to do all that may be reasonably required, to the satisfaction of the Client, to proceed with the Works.

7.3. **Notice of Claim**

(a) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Client and the Project Manager a notice of a claim for an extension of the Completion Date, together with particulars of the event or circumstance justifying such extension, as soon as reasonably practicable, after the commencement of such event or circumstance. Such notice provided by the Contractor to the Client and Project Manager shall include:

(i) the material circumstances of the event including the cause or causes;

(ii) the nature and extent of any delay;

(iii) the corrective action already undertaken or to be undertaken;

(iv) the period of any extension of time required for each component of the Works, so effected (as applicable); and

(v) a statement that it is a notice pursuant to this Clause 7.3.

(b) The Contractor shall ensure that the particulars provided to the Client and Project Manager under this Clause 7.3 are kept up to date and shall continuously submit such further particulars as may be necessary or which may be requested by the Client, from time to time.

7.4. **Minimize Delay**

The Contractor shall, at all times, use its reasonable endeavor's to minimize any delay in the performance of its obligations under the Contract.

7.5. **Concurrent Delays**

If there are concurrent causes of delay and both delays would entitle the Contractor to an extension of time under this Clause 7.5., then, to the extent of that concurrency, the Contractor shall only be entitled to claim an extension of time for that cause of delay which would entitle it to the longer period of extension.

7.6. **Rate of progress**

If for any reason, which does not entitle the Contractor to an extension of time, the rate of progress of the Works is at any time, in the opinion of the Client and/or the Project Manager, too slow to ensure completion of the Works within the time period specified in Clause 7.2., the Client shall notify the Contractor in writing and the Contractor shall promptly take all steps as are necessary and the Client may approve to expedite progress so as to complete the Works or such section by the prescribed time or extended time. The Contractor shall not be entitled to any additional payment for taking such steps.

8. MATERIALS AND WORKMANSHIP

8.1. **Quality of Materials and workmanship and tests**

All Materials and workmanship shall be as described in the Contract and in accordance with the Client's instructions and shall be subject from time to time to such tests as the Client may direct.

8.2. **Quality Assurance Programme**

The Contractor before the start of Works shall submit for approval a quality assurance programme to the Client indicating measures that it proposes to implement to ensure that the quality of Works shall be in accordance with requirements laid down in the Contract ("**Quality Assurance Programme**"). The Client and/or Project Manager may add such additional quality assurance measures as it considers appropriate for ensuring quality compliance of the Works. The Contractor shall strictly adhere to this programme and any failure attributable to the Contractor shall attract the penal provisions laid down in the Contract.

8.3. **Cost of samples/ Mock-ups / Tests**

(a) All samples/mock-ups shall be supplied by the Contractor at its own cost if the supply thereof is clearly intended by or provided for in the Contract.

(b) The Contractor shall provide samples for the approval of Client and shall provide alternative samples until the approval of the Client has been obtained. Samples approved by the Client shall be kept at Site under custody of the Contractor until completion of the Project.

(c) The cost of conducting any test shall be borne by the Contractor if such test is clearly intended by or provided for in the Contract and in the cases only of a test under load or of a test to ascertain whether the design of any finished or partially finished work is appropriate for the purposes which it was intended to fulfill, is particularized in the Contract in sufficient detail to enable the Contractor to price or allow for the same in its tender.

(d) The Contractor shall provide normal testing facilities at Site at its cost as directed by the Client and/or the Project Manager.

8.4. **Inspection of Works**

The Client and the Project Manager or any person authorized by them shall at all times have access to the Works and to all workshops and places where Works are being prepared or from where Materials, manufactured articles or machinery are being obtained for the Works and the Contractor shall afford every facility for and every assistance in or in obtaining the right to such access.

8.5. **List of approved brand and makes**

A list of approved brands and makes for Materials to be incorporated in the Works should be furnished by the bidder along with its tender. The Contractor shall submit samples of processed raw materials and Materials procured in conformity with Prudent Industry Practices for the approval of the Client and/or the Project Manager. Procurement of the Materials for the Works shall be after the approval of the Client and/or the Project Manager in writing.

8.6. **Basic Prices**

Basic price shall mean the cost of the Material per unit inclusive of all Taxes and duties, cost of transportation, loading, unloading, breakage, incidental charges, etc. All costs and expenses shall be deemed to be included in item rate quoted by the Contractor for that relevant item and shall not be entitled to claim any extra amounts on this basis. Goods and service tax, if applicable, in performance of the Works shall be calculated and shown separately in the Bidding Documents. The Contractor must provide break-up of all the tax components as applicable separately from the basic price.

8.7. **Removal of improper Materials**

The Client shall during the progress of the Works has power to order in writing from time to time:

(a) the removal from the Site, within such time or times as may be specified in the order, of any Materials, which, in the opinion of the Client, are not in accordance with the Contract or otherwise not fit for use in respect of the Works;

(b) the substitution of proper and suitable Materials and;

(c) the proper re-execution of any Works which in respect of Materials or workmanship is not in accordance with the Contract.

8.8. **Default of Contractor in compliance**

In case of default on the part of the Contractor in carrying out such order, the Client shall be entitled to engage and pay other persons to carry out the same and all expenses consequent thereon or incidental thereto shall be recoverable from the Contractor by the Client or may be deducted by the Client from any monies due to or which may become due to the Contractor.

8.9. **Quality Control Tests**

The Contractor shall perform the relevant tests as required under the scope of Works. The cost of all such tests so performed shall be borne by the Contractor and no extra amounts shall be borne by the Client on this account. The details of the quality tests to be carried out shall be as set out in Technical Specifications or notified by the Client and/or Project Manager.

9. PERFORMANCE PARAMETERS

9.1. **Tests**

The tests shall be conducted by the Contractor in the presence of the Client and/or the Project Manager in accordance with the testing procedures set out in **Schedule VIII** to the Contract, so as to ensure the operation of the New admin. & Engg. Block as an integrated whole to establish the Performance Parameters.

9.2. **Performance Tests**

The performance tests shall be conducted by the Contractor in the presence of the Client and/or the Project Manager in accordance with the performance testing procedures to the Contract, so as to ensure the operation of the New admin. & Engg. Block as an integrated whole to establish the Performance Parameters.

9.3. **Attainment of Performance Parameters**

The Contractor guarantees that during the performance tests, the New admin. & Engg. Block and all parts thereof, shall attain the Performance Parameters, subject to and upon the conditions specified herein.

9.4. **Consequences of Performance Parameters Not Being Met**

Subject to Clauses 9.1 and 9.2, if pursuant to conducting the tests and performance tests, the Performance Parameters are not met, either in whole or in part, the Contractor shall, at its cost and expense, make such changes, modifications and/or additions to the New admin. & Engg. Block, or any part thereof, as may be necessary to meet the Performance Parameters to the satisfaction of the Client. The Contractor shall notify the Client upon completion of the necessary changes, modifications and/or additions, carried out in accordance with this Clause 9.4, and shall request the Client to facilitate the repetition of the performance tests until the Performance Parameters have been met. If the Performance Parameters are not met, either in the whole or in part, even after 2 (two) such re-tests (after carrying out necessary changes, modifications, and/or additions), and the cap for the liquidated damages as provided in Clause 10.2. has been reached, then the Client may, at its sole discretion, exercise any one of the following options:

(a) reject the New admin. & Engg. Block, and recover all the payments already made to the Contractor in terms of the Contract;

(b) terminate the Contract and find a replacement contractor for undertaking the Works at the cost and risk of the Contract; or

(c) accept the deficient Works and proportionately reduce the Contract Price to reflect the diminished value to the Client, and such reduction shall be determined by the Client. The Client shall deduct from the Contract Price, the amounts payable for the defects in New admin. & Engg. Block and the Contractor shall proceed in accordance with all other obligations under the Contract.

9.5. **Liquidated Damages and Termination**

If the total amount of liquidated damages for shortfall in performance exceeds the amount of liquidated damages specified in Clause 10, the Client shall have the right to either:

(a) reject the Works and recover all the payment already made to the Contractor in terms of the Contract; or

(b) terminate the Contract pursuant to Clause 34 of the Contract.

10. LIQUIDATED DAMAGES

10.1. **Liquidated Damages for Shortfall in Performance of the Works**

The Contractor shall pay the liquidated damages as set forth in this Clause 10.1, if the New admin. & Engg. Block, or any part thereof, fails to meet:

10.2. **Liquidated Damages for Delay**

(a) If the Contractor fails to achieve completion of the Works on or before the expiry of the Completion Date, then the Contractor shall pay to the Client [1% (one percent)] of the Contract Price per week subject to maximum of [5% (five per cent)] of the total Contract Price as liquidated damages for every week or part thereof which shall elapse between the Final Completion and the date of issuance of the Final Acceptance Certificate. The Client may, without prejudice to any other method of recovery, deduct the amount of such damages from any monies in its hands, due or which may become due to the Contractor. The payment or deduction of such damages shall not relieve the Contractor from its obligation to complete the Works or from any other of its obligations and liabilities under the Contract.

(b) The Contractor recognizes and acknowledges that the Client would suffer substantial losses and damage if there is a delay in the completion of the Works.

(c) The payment of liquidated damages for delay under this Clause is in addition to, and without prejudice to, any other remedies that may be available to the Client under the Contract or Applicable Law.

(d) Without prejudice to any other rights the Client may have, the Client shall have the right to reject the Works if the quality of the Works does not meet the Technical Specifications set out in **Schedule X** and the Contractor is unable to correct the deficiencies in Works within [5 (five) days] of being asked to by the Client.

10.3. **Genuine Pre-estimate**

The Parties acknowledge that the damages, losses and costs incurred by the Client for delay in achieving completion of the Works by the Completion Date and for shortfall in performance are uncertain and difficult to determine with precision at the date of signing the Contract. The sums for liquidated damages for delay and liquidated damages for shortfall in performance as set out in this Clause 10.3 represent a reasonable, genuine and appropriate pre-estimate of the damages, losses and costs likely to be suffered by the Client if the delay or the shortfall in performance described in this Clause 10 occurs and are calculated as a best efforts attempt to quantify the Client's actual losses, costs and damages associated with such delay and shortfall in performance. The amounts due under this Clause 10.3, as liquidated damages, shall be payable by the Contractor, without any requirement of proof of the actual loss or damage caused by such delay and/or breach. The sums set out in this Clause 10 seek to limit the potential liability of the Contractor and constitute liquidated damages and not a penalty.

10.4. **Contractor's Obligations**

The payment of liquidated damages by the Contractor in terms of Clause 10.3, does not in any way relieve the Contractor from any of its duties, obligations and responsibilities under the Contract and shall be without prejudice to any other rights available to the Client under the Contract.

10.5. **Rights at Law**

If this Clause 10 (or any part hereof) is found for any reason to be void, invalid or otherwise in-operative so as to disentitle the Client from claiming liquidated damages, the Client is entitled to claim, damages in accordance with Applicable Law for the Contractor's delays or shortfall in performance of the Works for the New admin. & Engg. Block.

11. COMPLETION AND ACCEPTANCE OF WORKS

11.1. **Completion** The Works shall achieve completion, when each of the following has been completed to the Client's satisfaction ("**Completion**"):

(i) the New admin. & Engg. Block is functional in accordance with the requirements of the Contract, and the tests have been successfully completed in accordance with Clause 9.1.;

(ii) the Contractor has complied with all provisions of the Contract relating to the Works;

(iii) the Contractor has performed all its obligations and provided to the Client all Documents, that are due on or prior to the Completion Date, in accordance with the terms of the Contract; and

(iv) the Contractor has delivered to Client, the notice of completion: (a) certifying that all the conditions stated in this Clause 11.1 have been fully satisfied; and (b) accompanied by a

report of results of the tests and the Works completed with sufficient detail to enable the Client to determine whether Completion has been achieved ("**Notice of Completion**"). Provided, however, that if Client subsequently raises an objection to such Notice of Completion in accordance with Clause 11.1.(c), such notice will not be deemed to be delivered until any such objection is satisfied.

(a) Upon the Client and Project Manager being satisfied of completion with the Contractor set out in Clause 11.1.(a) above, they shall issue the completion certificate in a form and manner set out in **Schedule XI** ("**Completion Certificate**").

(b) Within 30 (thirty) days of receipt of the Notice of Completion, the Client shall notify the Contractor, of deficiencies and defects, if any, in relation to satisfying the provisions of Clause 11.1.(a) ("**Defects Notice**"). The Contractor shall, promptly upon receipt of the Defects Notice, perform at the Contractor's sole cost and expense, corrective measures to remove such deficiencies and shall deliver to the Client, a new Notice of Completion when completion of the applicable Works has been completed.

(c) Within 30 (thirty) days of receipt of the subsequent Notice of Completion, the Client shall notify the Contractor of additional or remaining deficiencies, if any, that must be corrected by Contractor as a condition to the Completion. Any Disputes regarding the existence or correction of any such alleged deficiencies shall be resolved pursuant to Clause 35 (Dispute Resolution).

(d) For the avoidance of any doubt, it is clarified that the issuance of the Completion Certificate by the Client shall in no way relieve the Contractor of its other obligations under the terms and conditions of the Contract or give rise to any liabilities for the Client.

11.2. **Provisional Acceptance**

(a) The New admin. & Engg. Block shall achieve provisional acceptance, when each of the following has been completed to Client's satisfaction ("**Provisional Acceptance**"):

(i) the Contractor has achieved Completion (Clause 11.1);

(ii) the Contractor has performed all its obligations under the Contract required to be performed;

(iii) the Contractor has successfully completed the tests required to ensure that the Works are reliable;

(iv) the Contractor has obtained the Occupancy Certificate for the New admin. & Engg. Block;

(v) the Contractor has removed from the Site, all scaffolding, rubbish, etc., and has cleaned the Site off all debris;

(vi) Client has received copies of all permits obtained by the Contractor required for the Works;

(vii) the Contractor has submitted all Documents (including the as-built plans pursuant to Clause 5.19 and Clause 14, and all other items and deliverables required to be submitted by the Contractor under the Contract;

(viii) the New admin. & Engg. Block is capable of being operated in accordance with Prudent Industry Practices;

(ix) the New admin. & Engg. Block is capable of being operated in accordance with Applicable Laws;

(x) the Client has received copies of all permits obtained by the Contractor pursuant to Clause 5.29.(c);

(xi) all Works have been completed to the satisfaction of the Client; and

(xii) no default pursuant to Clause 11.1.(c) exists.

The Contractor shall deliver to the Client, a notice of provisional acceptance, certifying that all the conditions set forth in this Clause 11.2.(a) have been fully satisfied, accompanied by a report of the Works completed with sufficient detail to enable the Client to determine whether Provisional Acceptance Certificate should be issued ("**Notice of Provisional Acceptance**").

(b) Upon the Client and Project Manager being satisfied of completion with the Contractor set out in Clause 11.2.(a) above, they shall issue the provisional acceptance certificate in a form and manner set out in **Schedule XII** ("**Provisional Acceptance Certificate**").

(c) Within [30 (thirty) days] of receipt of the Notice of Provisional Acceptance, the Client and/or the Project Manager shall notify the Contractor, of deficiencies, if any, in relation to satisfying the provisions of Clause 11.2.(a) ("**Provisional Defects Notice**"). The Contractor shall promptly upon receipt of the Provisional Defects Notice, perform at Contractor's sole cost and expense, corrective measures to remove such deficiency and shall deliver to Client a new Notice of Provisional Acceptance when completion of the applicable Works has been completed. Within [30 (thirty) days] of receipt of the subsequent Notice of Provisional Acceptance, Client and/or Project Manager shall notify Contractor of additional or remaining deficiencies, if any, that must be corrected by Contractor as a condition to the issuance of the Provisional Acceptance Certificate. Any Disputes regarding the existence or correction of any such alleged deficiencies shall be resolved pursuant to Clause 35 (Dispute Resolution).

(d) In the event the items stated under Clause 11.2(a)(v) have not been removed within [30 (thirty) days] of the issuance of the Provisional Acceptance Certificate, the Client may sell or otherwise dispose of the same. The Client shall be entitled to be paid the costs incurred in connection with, or attributable to, such sale or disposal and restoring the Site. Any balance of monies from the sale shall be paid to the Contractor.

(e) The issuance of the Provisional Acceptance Certificate by the Client and/or Project Manager shall in no way relieve the Contractor of its other obligations under the terms and conditions of the Contract or give rise to any liabilities for the Client.

11.3. **Final Acceptance Certificate and Final Completion**

(a) The New admin. & Engg. Block shall achieve final completion, when each of the following has been completed to Client's satisfaction and the Contractor has performed all other obligations under the Contract, which are required to be performed prior to the issuance of the Final Acceptance Certificate ("**Final Completion**"):

(i) the Contractor has achieved Provisional Acceptance;

(ii) the Contractor has executed Works to the sole satisfaction of the Client;

(iii) the Contractor has paid all liquidated damages, indemnity sums and other payments due from the Contractor under the Contract;

(iv) the Contractor has assigned to the Client or provided Client with all warranties or guarantees that Contractor has received from Sub-Contractors to the extent Contractor is obligated to do so pursuant to the Contract;

(v) all Contractor's Materials and other supplies, equipment, surplus, waste, huts, wreckage, debris, rubbish, and temporary facilities to which Client does not, and is not entitled to hold title, have been removed from the Site, and the Site have been restored in accordance with the terms of the Contract provided that, all activities in relation to clearing and disposal shall be conducted in accordance with all Applicable Laws;

(vi) all the Contractor's Personnel and the personnel of the Sub-Contractors and their personnel, have been removed from the Site;

(vii) all Sub-Contractors have been paid their dues by the Contractor and Contractor has delivered the final release and waiver of Liens and claims pursuant to the Contract and has delivered such other documents and certificates as Client has reasonably requested to ensure compliance with all Applicable Laws;

(viii) all activities required as per Applicable Law on account of the completion of the Works have been completed by the Contractor;

(ix) the Contractor has delivered to Client a notice of final completion: (a) certifying that all the conditions set forth in this Clause 11.3.(a) have been fully satisfied; and (b) accompanied by a report of the Works completed with sufficient detail to enable the Client to determine whether Final Completion has been achieved ("**Notice of Final Completion**"). Provided, however, that if the Client subsequently raises an objection to such notice in accordance with Clause 11.3(c), such Notice of Final Completion will not be deemed to be delivered until any such objection is satisfied.

(b) Upon the Client and Project Manager being satisfied of completion with the Contractor set out in Clause 11.3.(a) above, they shall issue the final acceptance certificate in a form and manner set out in **Schedule XIII** ("**Final Acceptance Certificate**").

(c) Within [30 (thirty) days] after receipt of the Notice of Final Completion, the Client and/or the Project Manager shall notify the Contractor, of deficiencies, if any, in relation to satisfying the provisions of Clause 11.3.(a) ("**Acceptance Defects Notice**"). The Contractor shall promptly upon receipt of the Acceptance Defects Notice perform at Contractor's sole cost and expense, corrective measures to remove such deficiency and shall deliver to Client, a new Notice of Final Completion when completion of the applicable Works has been completed. Within [30 (thirty) days] of receipt of the subsequent Notice of Final Completion, Client and/or the Project Manager shall notify Contractor of additional or remaining deficiencies, if any, that must be corrected by Contractor as a condition to the Final Completion. Any Disputes regarding the existence or correction of any such alleged deficiencies shall be resolved pursuant to Clause 35 (Dispute Resolution).

(d) Without prejudice to Clause 11.3.(a), additional conditions may be agreed to between the Client and the Contractor, as conditions for issuance of the Final Acceptance Certificate.

(e) For the avoidance of any doubt, it is clarified that the issuance of the Final Acceptance Certificate by the Client shall in no way relieve the Contractor of its other obligations under the terms and conditions of the Contract or give rise to any liabilities for the Client.

11.4. **Take Over**

(a) Upon the issuance of the Final Acceptance Certificate, the Contractor shall handover to the Client and the Client shall take possession and control of the New admin. & Engg. Block ("**Take Over**") and shall issue to the Contractor, a take over certificate in a form and manner set out in "**Take Over Certificate**". Upon such Take Over, the Client shall, except as otherwise provided, be responsible for the risk of loss or damage to the New admin. & Engg. Block.

(b) Prior to the possession and control of the New admin. & Engg. Block being handed to the Client in terms of this Clause 11.4, the Contractor shall be responsible and take care of the New admin. & Engg. Block/ Project in a manner consistent with Applicable Laws, Prudent Industry Practice and the other requirements set forth in the Contract. The transition of such possession and control of the New admin. & Engg. Block from Contractor to Client as set forth in this Clause 11.4 shall be accomplished in accordance with the procedures to be set forth in a transition plan to be submitted by Contractor (in a form acceptable to the Client) to the Client, for its approval, no later than [15 (fifteen) days prior] to the anticipated date of Final Completion.

12. PROJECT MANAGER

12.1. The Contractor acknowledges and agrees that the Client has appointed the Project Manager for the supervision and management of the Works to be undertaken by the Contractor and ensure completion of Works in the time period specified under Clause 7. The Contractor shall coordinate with the Project Manager while carrying out the Works. The Contractor acknowledges and agrees that any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by the Project Manager shall have the same effect as though the act had been an act of the Client. However:

(a) it shall not relieve the Contractor from any responsibility it has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances;

(b) any failure to disapprove any Works, Contractor's Equipment or Materials shall not constitute approval, and shall therefore not prejudice the right of the Client to reject the Works, Contractor's Equipment or Materials; and

(c) if the Contractor questions any determination or instruction of the Project Manager, the Contractor may refer the matter to the Client, who shall promptly confirm, reverse or vary the determination or instruction.

12.2. The Project Manager may issue to the Contractor instructions which may be necessary for the Contractor to perform its obligations under the Contract. Each instruction shall be given in writing and shall state the obligations to which it relates and the sub-clause (or other term of the Contract) in which the obligations are specified.

12.3. The Contractor shall comply with instructions from the Project Manager, or from the Client, including but not limited to:

(a) inspect and examine the Works before covering up and generate quality report;

(b) certification of bills in the manner satisfactory to the Client; and

(c) inspect and approve the mock-ups, quality of Materials and workmanship.

Notwithstanding any of the above, the Project Manager and the Architect shall, without prejudice, perform actions and deeds as also listed elsewhere in the Contract or in the agreement for appointment of the Project Manager by the Client.

12.4. The Project Manager shall be at liberty to object to and require the Contractor to remove forthwith from the Site engaged in the undertaking of Works any person provided by the Contractor who, in the opinion of the Project Manager, misconducts himself, or is incompetent or negligent in the proper performance of its duties, or whose presence on Site is otherwise considered by the Project Manager to be undesirable, and such person shall not be again allowed upon the Works without the consent of the Project Manager. Any person so removed from the Site for the performance of the Works shall be replaced as soon as possible.

13. ARCHITECT

13.1. The Client has appointed an architect for the purposes of designing the New admin. & Engg. Block ("**Architect**"). The Contractor shall co-operate and coordinate with the Architect and the Client to ensure that the Works are completed in accordance with the provisions of the design of the Architect as supplied to the Contractor as part of the Technical Specifications.

13.2. The Architect may shall depute a representative at the Site for performing the duties and obligations of the Architect specified herein and as set out in the agreement entered into between the Architect and the Client.

13.3. The Contractor acknowledges and confirms that the Architect or any representative of the Architect shall be entitled to inter alia the following items:

(a) give instructions to the Contractor in matters pertaining to the design, Drawings and specifications and completion of the Works; and

(b) give notice to the Contractor of non-approval of any Works or Materials, and such Works shall be suspended or the use of such materials shall be discontinued until the decision of the Client, but such examination shall not in any way exonerate the Contractor from the obligation to remedy any defects which may be found to exist at any stage of the Works or after the same is completed.

13.4. The Contractor shall provide the Architect access to the Site to inspect the Works and provide every facility and assistance for inspecting the Works.

14. DOCUMENTS

14.1. Documents Schedule

The Contractor shall, in accordance with the timelines specified in the Technical Specifications, provide to the Client a complete list of all Documents, which shall be utilized by the Contractor for the purpose of

completion of the Works. The said list of Documents shall clearly indicate the Document number in accordance with the codes, title, revision number, and issue number in accordance with Prudent Industry Practice together with the date on which such Document has been issued. Further, Drawings in relation to the layout of the New admin. & Engg. Block shall clearly provide for the north direction and shall depict grid lines at the scale of [__] meters which lines shall be submitted after a detailed survey carried out by the Contractor. The Contractor shall, if required by the Client, submit a revised schedule of the said Documents, till such time that all Works in relation to the fabrication of the New admin. & Engg. Block are completed by the Contractor. The Contractor shall, at its own cost, supply reduced size prints of all Documents, as and when required by the Client.

14.2. **Specification and Data Sheets**

The Contractor shall, within the time specified in the Technical Specifications, submit to the Client, an updated list of all specifications and data sheets required for undertaking the Works. The said data sheets shall indicate the account number, title, revision number and date of issuance of such sheets, so that an updated summary of the latest specifications, is at all times available with the Client, for reference. The procedure for the submission of revisions, if any to the said data sheets shall be as per the procedure set out for the revision of Documents pursuant to this Clause 14.2.

14.3. **As-Built Plans**

(a) The Contractor shall prepare and maintain an updated and complete set of as-built records of the New admin. & Engg. Block, identifying the precise as built locations, sizes and details of the Works executed. The Contractor shall ensure that all such records are maintained at the Site and shall be exclusively used for the purpose of the Contract.

(b) The Contractor shall, in accordance with this Clause 14, submit to the Client, for its review and comments, (along with the other Documents), plans of the Works for the New admin. & Engg. Block, depicting all executed Works. If any errors are found in the as-built plans, such errors shall be corrected at the Contractor's cost and expense. Unless otherwise provided, as-built plans of the New admin. & Engg. Block and related documents submitted by the Contractor for review under this Clause 14.3.(b) shall be reviewed within 15 (fifteen) days from the date of submission to the Client. If the Client does not provide any comments on the Documents submitted by the Contractor within such 15 (fifteen) days review period then it would be deemed that the Client has no comments on the said as-built plans.

(c) The Contractor shall submit 2 (two) copies of the as-built records to the Client. Further, upon completion of the ELECTRICAL AND ELV phase of the New admin. & Engg. Block, the Contractor shall complete the related plans in relation to the as-built stage (excluding all vendor drawings) and submit to the Client the following:

(i) [3 (three)] complete sets of all Documents on compact disc or other acceptable electromagnetic or electronic media, as may be required by the Client;

(ii) [5 (five)] complete sets of full size prints of the Documents;

(iii) [5 (five)] complete sets of data books specifying all details of the New admin. & Engg. Block in hard binders including certified prints and data for specialty materials to be provided under the Contract. All data books provided by the Contractor under this Clause shall be complete with index for tag numbers associated with the manufacture’s data. Data books shall be bound in volumes, limited to a maximum of 3 (three) inches in thickness;

(iv) [3 (three)] sets of as-built data filled in computer data entry forms; and

(v) [3 (three)] copies of all the Documents information in the form of compact disc or other acceptable electromagnetic or electronic media, as may be required by the Client.

(d) Provided that, in the event the Contractor designs the soft copies, it shall also provide a copy of that version along with its complete documentation. The Contractor shall, [15 (fifteen)] days prior to the issuance of the Final Acceptance Certificate, submit [5 (five)] sets of hard copy outputs of all the Documents to the Client.

14.4. **Data**

(a) The Contractor shall, in accordance with the timelines specified in the Technical Specifications provide such other structural drawings, instruction systems descriptions, Documents and Drawing indexes, computer control keys, computer programs, passwords and all other related data for the New admin. & Engg. Block containing the information necessary to enable the Client to use the New admin. & Engg. Block in accordance with Applicable Law.

(b) The Contractor shall, in accordance with the timelines specified in the Technical Specifications provide the Client with data books, vendor prints, complete Drawing lists, descriptions of the New admin. & Engg. Block and other specific information on the New admin. & Engg. Block.

14.5. **Review of Documents by the Client and/or the Project Manager**

(a) The Contractor shall provide to the Client, free of cost, all Documents in accordance with the Technical Specifications and Applicable Law. All Documents submitted by the Contractor shall be written in English language. The Contractor shall prepare all the Documents, and shall also prepare any other documents that are necessary so as to instruct the Contractor's personnel with regard to the completion of the Works.

(b) The review of Documents by the Client shall cover only general conformity of the Documents to the Technical Specifications, interfaces with the specification of the New admin. & Engg. Block provided under the Technical Specifications, external connections and of the dimensions which may affect the layout of the New admin. & Engg. Block.

(c) This review by the Client may not indicate a thorough review of all dimensions, quantities and details of the New admin. & Engg. Block, any devices or items indicated or the accuracy of the information submitted. This review by the Client shall not be construed by the Contractor, as limiting any of its responsibilities and liabilities for mistakes and deviations from the requirements, specified under the Technical Specifications and the Contract. Any activity forming part of the Documents not particularly described in the Contract shall also be included in the obligations of the Contractor and the omission from the Documents of such activity necessary and obviously intended shall not relieve the Contractor from performing such activity. For the avoidance of doubt, it is clarified that Contractor shall await the expiry of the period specified in Clause 14.2 during which the Client is required to review the Documents, prior to commencing the related Works, and if the Contractor executes the related Works prior to the expiry of such period of the Documents, the same shall be at the sole risk and cost of the Contractor.

14.6. **Mode of Submission**

(a) Unless otherwise provided or agreed to by the Client, the Contractor shall, in accordance with the timelines specified in the Contract, submit to the Client, all Documents specified in the Contract, as being required to be submitted for the review by the Client, along with a notice as specified below.

(b) The Documents to be submitted by the Contractor in accordance with this Clause 14.6 shall be submitted:

(i) in 2 (two) sets of soft copy using an internationally recognized web-based document viewing system, acceptable to the Client, linking the Client, the Contractor and the Sub-Contractors and [4 (four)] sets of hard copy;

(ii) along with a notice which shall state that the said Document is considered ready for both, (i) review by the Client in accordance with this Clause 14.2, and (ii) for use. The notice to be submitted by the Contractor shall also state that the said Document complies with the provisions of the Contract, or, if applicable, the extent to which it does not comply.

(c) Without prejudice to the above, any Document, when issued to the Client, shall clearly evidence on such Document itself, the prior approval of the Contractor with respect to such Document. The Client may reject, without further review, any Document submitted by the Contractor, which in the opinion of the Client (i) has not been subjected to the Contractor's quality assurance system submitted pursuant to Clause 9.2; or (ii) contains an unusual amount of errors or (iii) is otherwise sub-standard.

(d) Notwithstanding review by the Client of the Documents to be submitted by the Contractor pursuant to this Clause 14.2, the Contractor shall continue to be responsible for any errors, omissions or discrepancies therein. The Contractor shall bear any costs as a result of delay in providing such Documents or as a result of errors, omissions or discrepancies therein. The Contractor shall bear the cost of any alterations or remedial work necessary due to such errors, omissions or discrepancies for which the Contractor is responsible and shall modify the Documents accordingly. The performance of its obligations under this Clause 14.2 shall not relieve the Contractor of liability for delay in the completion of the Works under the Contract.

(e) Unless otherwise provided in the Technical Specifications or the Contract, Documents submitted by the Contractor for review, shall be reviewed within 14 (fourteen) days from the date of submission of the respective Document along with the notice specified in Clause 10.2(b), to the Client. If the Client fails to intimate the Contractor with regard to its decision on a Document, within the 14 (fourteen) day period specified in this Clause 14.2, then, such Document shall be deemed to have been reviewed by the Client. The Contractor shall, within 5 (five) days of intimation from the Client with regard to the review of the Documents, or a deemed review of such Document in accordance with this Clause 14.6., as the case may be, submit 6 (six) hard copies and 6 (six) soft copies in electronic form (in compact discs). Any Documents submitted by the Contractor, if in electronic form, shall be in a format acceptable to the Client.

14.7. **Correction of Documents**

(a) Without prejudice to Clause 14.3.(b), the Client may, at any time during the 15 (fifteen) day period specified in Clause 14.3, provide a notice to the Contractor that a Document has failed (to the extent stated) to comply with the provisions of the Contract. Upon receipt of a notice from the Client in terms of this Clause 14.7, the Contractor shall, at its own cost, promptly and in any case no later than 15 (fifteen) days from the receipt such notice, rectify the said Document and resubmit the same for the approval of the Client.

(b) Unless otherwise provided, if any of the information submitted to the Client, in the Documents is substantially in variance with the Technical Specifications, which in the opinion of the Client is unacceptable, such Documents shall be returned to the Contractor marked "**Rejected**" and the Contractor shall re-submit the said Documents. For the avoidance of doubt, it is clarified that no

extension of time shall be granted under this Clause 14.7 due to the Documents not being acceptable to the Client, in the first instance. In addition, the Client shall have the right to request the Contractor to make any change in the Documents that may be necessary to make the New admin. & Engg. Block conform to the Technical Specifications and the Contract, at the cost and expense of the Contractor.

14.8. **Responsibility of Documents**

(a) The Contractor hereby acknowledges that certain identified Documents forming part of the Technical Specifications have, as at the date hereof, been reviewed by the Client and the Contractor shall not, while executing the Works, depart from such Documents, unless consented to in advance by the Client. The Contractor shall be responsible for the accuracy of the Documents and any discrepancies, errors or omissions in the Documents and other particulars supplied by it, regardless of whether such Documents and particulars have been reviewed by the Client. If a Party becomes aware of an error or defect of a technical nature in a Document which was prepared for use, for the purpose of executing the Works, the Party shall promptly give notice to the other Party of such error or defect. If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in any Document provided by the Contractor, such Document, along with the Works corresponding to such Document, shall be corrected at the Contractor's cost and expense, notwithstanding the review by the Client of such Document. If the Documents have been previously reviewed by the Client, the Contractor shall not, during the completion of the Works, depart from the reviewed Documents, unless consented to in advance by Client. Review by the Client shall in no way relieve the Contractor of its obligations under the terms and conditions of the Contract or give rise to any liabilities for the Client.

(b) The Contractor's obligation to complete the Works shall not be reduced or affected by review of any Documents or specifications by the Client.

(c) Unless handed over by the Contractor to the Client, in accordance with the provisions of this Clause 14, the Documents shall, at all times, be in the care and custody of the Contractor.

14.9. **Documents and Specifications for Works**

(a) The Contractor shall, in accordance with the timelines specified in the Technical Specifications, submit to Client, for its review, in accordance with the procedure set out in Clause 14, details of the process package, layout Documents, detailed Documents, design specifications, detailed calculations and purchase specifications, etc., and any other information required by Client prior to issuing the same for the purpose of construction and development of the New admin. & Engg. Block. Within 7 (seven) days of the review by the Client of the Documents to be submitted in terms of this Clause 14.9.(a), the Contractor shall submit to the Client, Document lists, indicating the date of availability of the latest copy of such Document with date of review by the Client of each such Document released for ELECTRICAL AND ELV purposes.

(b) The Contractor shall ensure that all Documents submitted in terms of this Clause 14.9.(b) are made to a reasonable scale and are made in sufficient detail, as mutually agreed between the Parties, and in the event of any non-compliance with the same, necessary changes shall be made by the Contractor, at its own cost.

(c) Unless the Contractor requests the Client for a specific deviation from the specifications in relation to the Documents submitted pursuant to this Clause 14.9. and the Client issues a written authority to deviate from the said specifications, the submission and correction, if any, of the Documents

submitted pursuant to this Clause 14.9.(c), shall not relieve the Contractor of its responsibility to comply with the specifications specified in the Contract.

(d) The Contractor shall ensure that all Documents to be submitted by it pursuant to this Clause 14 are submitted in accordance with the time lines specified in the Technical Specifications. For the avoidance of doubt, it is clarified that at no given point of time, will the Contractor rely on preliminary drawings for the purpose of construction and development of the New admin. & Engg. Block.

(e) The Parties shall follow the following procedure in relation to the submission and subsequent review of the Documents submitted under this Clause 14:

(i) The Contractor shall submit to the Client, no later than the time specified in the Technical Specifications, copies of all preliminary Drawings and specifications in accordance with the requirements of the Technical Specifications;

(ii) The Client shall review the preliminary Drawings submitted in terms of Clause 14 and notify the Contractor, of any comments or suggestions by returning a marked-up print or copy of the said Drawings to the Contractor.

(iii) If the Client returns to the Contractor, marked-up Drawings or if the comments on Drawings and specifications are returned pursuant to Clause 14, the Contractor shall, promptly and in any event no later than 7 (seven) days from the receipt of the same, carry out the requisite corrections and obtain the Client's approval in relation to the said corrections, before issuing the same for the purpose of construction and development of the New admin. & Engg. Block.

(iv) The Contractor shall not modify any Documents submitted pursuant to this Clause 14 after the same have been reviewed by the Client. Provided that, if the Contractor is desirous of modifying any item issued for the purpose of construction and development of the New admin. & Engg. Block, as depicted on the Documents which have been submitted and reviewed in terms of this Clause 14, it shall submit to the Client the revised Documents and modified prints in relation to the same and follow the procedure set forth in this Clause.

(f) The procedure stated in this Clause 14 shall apply *mutatis mutandis* to all applicable Documents submitted by the Contractor, during the construction and development of the New admin. & Engg. Block.

15. CONTRACTOR TO INFORM ITSELF FULLY

15.1. Information

(a) The Contractor shall be responsible for obtaining all information required for the performance of its obligations under the Contract.

(b) The Contractor has clarified and carefully examined all the Documents, design criteria, calculations, (if any) data, Technical Specifications and such other matters as may be necessary or desirable for performing its obligations under the Contract, to its entire satisfaction. The Contractor shall not, except as expressly provided in the Contract, be entitled to any extension of time or to any adjustment of the Contract Price, on grounds of misinterpretation or misunderstanding of any such matter.

(c) The Client shall not be responsible for any error, inaccuracy or omission of any kind in the Technical Specifications as originally included in the Contract and shall not be deemed to have given any representation of accuracy or completeness of any data or information. Any data or information received by the Contractor, from the Client or otherwise, shall not relieve the Contractor from its responsibility of completion of the Works.

(d) The Contractor has, prior to the execution of the Contract Agreement obtained all information and taken into consideration the restrictions imposed by the necessity to coordinate its activities for the New admin. & Engg. Block to be constructed and developed with the mutually agreed times.

15.2. **Local Conditions**

The Contractor represents that it is fully informed of all general and local conditions near the Site and other factors that may have an effect on the compliance of its obligations under the Contract. The Contractor cannot claim a Change under Clause 22 (Change in Contract Elements), an extension of time or an increase in the Contract Price as a result of such local conditions or factors.

15.3. **Site and the New admin. & Engg. Block**

(a) The Contractor represents and confirms that it has entered into the Contract Agreement on the basis of its proper examination of the Site by its checking or carrying out its own investigations as may be required, including the suitability and availability of the access routes thereto and that it is aware about the conditions of the Site and its surroundings and has satisfied itself as to all technical, commercial, social and general conditions of and all circumstances affecting the Site, including the nature of the ground and sub-soil, Site surroundings, environmental aspects, the form and nature of the Site and the exact location and condition, as may be required. In this regard, the Contractor has obtained for itself all information, as may be necessary or desirable for the compliance of its obligations under the Contract, including all necessary information as to the risks, contingencies, climatic, hydrological, natural conditions and all other circumstances which may influence or affect the Contract Price and/or its obligations under the Contract. Further, the Contractor agrees that if during the term of the Contract, any portion of the Site is rendered unsafe, on account of any reason whatsoever (including unfavourable weather), the Contractor shall restrict the completion of the Works, to such portion of the Site which is safe and not affected by the said contingency. The Contractor represents and confirms that by signing the Contract Agreement, the Contractor accepts total responsibility for having foreseen all difficulties and costs of successfully completing the Works and that the effect of all contingencies have been considered by the Contractor prior to entering into the Contract Agreement and that the Contractor shall not be entitled to extension of time or an increase in the Contract Price on account of the same.

(b) The Contractor represents and confirms that it has entered into the Contract on the basis of a proper examination of the data relating to the New admin. & Engg. Block on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the New admin. & Engg. Block. The Contractor acknowledges that any failure to verify and interpret any data and information in relation to the Site and/or the New admin. & Engg. Block shall not relieve it of its responsibility for properly estimating the difficulty or cost of successfully performing its obligations under the Contract.

16. SUB-CONTRACTORS

16.1. **Experience**

The Contractor represents that each Sub-Contractor has the requisite skill, expertise, experience, capacity, capability and has successfully executed works similar to the Works, in the immediately preceding [3 (three) years] from the Commencement Date.

16.2. **List of Sub-Contractors**

A list of all major items and the approved Sub-Contractors for each of such major items has been provided by the Contractor and incorporated in the Technical Specifications. The Client and the Contractor have agreed on a list of approved Sub-Contractors, from the list provided in the Technical Specifications, and the same is set out in **Schedule XV** (Approved List of Sub-Contractors) ("**Approved List**"). The Client, after due consultation and agreement with the Contractor, shall have the right to add or delete from the Approved List, from time to time, and approve any successor or replacement of any person listed on the Approved List.

16.3. **Sub-Contracting**

With regard to major items, as specified in the Technical Specifications, the Contractor shall, subject to Clause 16.2, only contract with the Sub-Contractors provided in the Approved List. Further, any sub-contracting in terms of this Clause 16.3, shall not relieve or discharge the Contractor from any of its liabilities or obligations under the Contract and the Contractor shall be responsible for the acts, defaults and neglects of all Sub-Contractors and its agents, servants or workmen, or any of them, as fully, as if they were the acts, defaults or neglects of the Contractor under the terms of the Contract and the Client shall not be liable on account of the same. No acts or omissions on the part of any of the Sub-Contractors will allow the Contractor to claim an extension of time, an increase in the Contract Price, or any other dispensation pursuant to the Contract.

16.4. **Other Sub-Contractors**

If the Contractor intends on contracting with Sub-Contractors, other than those specified in the Approved List, the Contractor shall provide the Client with details in relation to the same. The Client shall, no later than 10 (ten) days from such additional details being provided by the Contractor, approve or disapprove the same. In the event the Client approves the additional Sub-Contractors in terms of this Clause 16.4, such additional Sub-Contractors shall be deemed to be included in the Approved List. The Client shall also have the right to propose a Sub-Contractor other than those specified in the Approved List and upon mutual agreement with the Contractor in this regard, require the Contractor to contract with such Sub-Contractor. In the event of such mutual agreement, the sub-contractor proposed by the Client shall be deemed to be included in the Approved List. Provided that, any agreement between the Parties in terms of this Clause 13.4 shall not relieve or discharge the Contractor from any of its liabilities or obligations under the Contract and the Contractor shall be responsible for the acts, defaults and neglects of all such Sub-Contractors and its agents, servants or workmen, or any of them, as fully, as if they were the acts, defaults or neglects of the Contractor under the terms of the Contract.

16.5. **Client's Consent**

The Contractor shall not sub-contract the whole of its obligations under the Contract. Notwithstanding the Client's consent to any Sub-Contractor, the Contractor shall at all times remain fully responsible to the Client for the proper performance of its obligations under the Contract. The Client shall, at no given point of time, be considered to have any duties or obligations towards any Sub-Contractor as a result of the Contract or by virtue of providing its consent to the Contractor with respect to a Sub-Contractor. The

Contractor shall not be relieved of any obligation or responsibility under the Contract by subcontracting of any portion of the Works to a Sub-Contractor.

16.6. **Copies of Sub-Contracts**

The Contractor shall, upon request, provide to the Client copies of technical ordering specifications and principal commercial terms (un-priced) of the sub-contracts with regard to the major items as identified in the Technical Specifications, to be executed with the Sub-Contractors.

16.7. **Form of Sub-Contracts**

(a) The Contractor shall ensure that all contracts with its Sub-Contractors are made in writing. The Contractor shall also ensure that each Sub-Contractor includes provisions which will entitle the Contractor to discharge its obligations and liabilities to the Client in terms of the Contract. The Contractor shall further ensure that all contracts with the sub-contractors shall require each Sub-Contractor, to the extent of the Works to be performed by the Sub-Contractor, to be bound by the terms of the Contract and to assume toward the Contractor all the obligations and responsibilities which the Contractor, by the Contract, assumes toward the Client. Each contract with a Sub-Contractor shall preserve and protect the rights of the Client under the Contract with respect to the Works being performed by the Sub-Contractor so that such sub-contracting does not prejudice the rights of the Client.

(b) Each instrument evidencing any contract with its Sub-Contractors shall provide that, pursuant to its terms, in form and substance satisfactory to the Client, the rights of the Contractor under such contract with its Sub-Contractors (including all warranties provided by the sub-contractor) are assignable to the Client. The Contractor shall assign to the Client, its successors and assigns, any such contract with its Sub-Contractors as may be required by the Client in its sole discretion, prior to the issuance of the Final Acceptance Certificate or following termination of the Contract, as the case may be.

16.8. **Client's Rights**

The Contractor warrants that no arrangement, agreement or understanding with any sub-contractor shall directly or indirectly interfere with, restrict or impede the Client in the exercise of any right or remedy under the Contract.

16.9. **Evidence of Payment**

(a) The Contractor shall promptly pay all amounts due to any Sub-Contractor. The Contractor shall, by an appropriate agreement with each Sub-Contractor, require each Sub-Contractor to make payments to its sub-contractors, if any, in a timely manner. The Client shall have no obligation to pay or to verify the payment of any monies to any sub-contractor. However, the Client may, at its discretion, verify the payments made by the Contractor to the Sub-Contractors.

(b) The Contractor shall provide to the Client documentary evidence that the Contractor has made or caused to be made all payments due to its Sub-Contractors and when final payment has been made to the Contractor under the Contract, that the Contractor has made final payment to its Sub-Contractors.

17. TRANSFER OF OWNERSHIP

17.1. **Ownership**

The ownership of the New admin. & Engg. Block shall, at all times vest with the Client. Without prejudice to this Clause 17.1, the Contractor shall, until the issuance of the Take Over Certificate, be responsible for the care of the New admin. & Engg. Block, together with the risk of damage thereto. After the issuance of the Take Over Certificate, the Client shall be responsible for the care of the New admin. & Engg. Block, provided that any damage to the New admin. & Engg. Block on account of reasons attributable to the Contractor, shall at all times during the term of the Contract and the expiry of the Defect Liability Period, be to the Contractor's account.

17.2. **Warranty as to Title**

The Contractor warrants that the Contractor's equipment and material shall remain free from defects in title including liens of any kind. The Contractor shall defend the title to the same against any third party and shall indemnify, defend and hold the Client harmless from and against any and all losses arising out of or otherwise resulting from any failure to comply with this Clause 17.2.

17.3. **Ownership of the Contractor's equipment & materials**

The ownership of the Contractor's Equipment, used by the Contractor or its Sub-Contractors, shall at all times remain with the Contractor**.**

17.4. **Excess Material**

The ownership of any Materials, in excess of the requirements for the New admin. & Engg. Block, as may be determined by the Client and Contractor, shall vest with the Contractor.

18. REPRESENTATIONS AND WARRANTIES

18.1. **Contractor's Representations and Warranties**

The Contractor makes the following representations and warranties to the Client, each of which is true and correct as on the date of issuance of Letter of Award which representations and warranties shall continue to be true and correct throughout the term of the Contract:

(a) it has been incorporated as a company under the Companies Act, [1956/2013], is validly existing and has the power and authority to carry on its business in India;

(b) it has the power to enter into the Contract and comply with its obligations under it;

(c) it has in full force and effect the authorizations necessary for it to enter into the Contract and the transactions contemplated under it;

(d) it has satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract; and

(e) it and its Sub-Contractors have the requisite knowledge, skill, experience, expertise, capacity and capability to execute the Works in a timely manner and to satisfy and fulfill all their respective obligations and responsibilities under the Contract.

18.2. **Client's Representations and Warranties**

The Client makes the following representations and warranties to the Contractor, each of which is true and correct as on the date of issuance of Letter of Award which representations and warranties shall continue to be true and correct throughout the term of the Contract:

(a) it has been incorporated as a company under the Companies Act, 2013, is validly existing and has the power and authority to carry on its business in India;

(b) it has the power to enter into the Contract and comply with its obligations under it;

(c) it has in full force and effect the authorizations necessary for it to enter into the Contract and the transactions contemplated under it; and

(d) it shall, with the necessary assistance of the Contractor, as and when required, acquire permits, approvals and/or licenses specified in the Technical Specifications.

19. WARRANTIES

19.1. Contractor's Warranties

The Contractor hereby warrants to the Client that the New admin. & Engg. Block has been and shall have been engineered, designed, tested and the Works shall be executed in a manner consistent with the terms of the Contract, in accordance with Prudent Industry Practices and Applicable Law,

(a) using the skill, care and diligence to be expected of appropriately qualified and experienced professionals with experience in ELECTRICAL AND ELV works of a type, nature and complexity similar to the ELECTRICAL AND ELV in the industry;

(b) in accordance with good modern engineering principles and of appropriate grade compatible with the intended purpose;

(c) using only Materials and goods for incorporation into the New admin. & Engg. Block which are new, and do not contain any refurbished components, are free of lien and encumbrances, are unused and the standards of all workmanship, manufacture and fabrication have conformed in all respects to the Technical Specifications, and shall be of such quality as is intended for the purpose for which it is intended;

(d) using the standards of all workmanship and fabrication which conform in all respects to the Codes and Standards and being of such quality as is intended for the purpose for which it is intended;

(e) conforming to the Technical Specifications and being free of defects and deficiencies. The engineering and design shall be such that the Works shall meet all safety and applicable criteria as specified in the Contract;

(f) being suitable for the use in accordance with the requirements necessary to meet the Performance Parameters;

(g) using means, methods and techniques required for the completion of the Works which are appropriate for the conditions and materials involved and in accordance with the current state of the art; and

(h) ensuring that the Works when completed will conform in all respects with the requirements of, and will be suitable for, the purpose of the Contract.

19.2. Other Warranties

The New admin. & Engg. Block shall:

(a) upon Final Completion, be in accordance with all requirements of the Contract unless otherwise agreed by the Client, or altered in accordance with a Change in accordance with Clause 22 (Change in Contract Elements) instructed by the Client;

(b) be capable of being operated in accordance with the requirements of the Contract and Prudent Industry Practices; and

(c) comply with Applicable Law in effect on the Final Completion Date.

20. INSURANCE

20.1. Insurance Policies

(a) All insurance policies, whether required to be obtained under this Clause 20 or otherwise, wherever possible shall be taken out in the joint names of the Client, the Contractor and Sub-Contractor, wherever applicable.

(b) All the insurance shall be arranged by Contractor from a reputable insurance company which can deal with all matters pertaining to the subject and is acceptable to the Client. The Client has reserved its right to nominate the insurance company or take the insurance policies under which the claims will be lodged by the Contractor.

(c) The Contractor must ensure that the policy amounts cover the Contract Price and adequately cover the maximum possible liability that may arise on the occurrence of the risks covered.

(d) The Contractor shall deposit the original insurance policy and the premium paid receipts with the Client on the date of issuance of the Letter of Award. If the Contractor fails to procure such policy or deposit the same and the premium receipts in original with the Client, the Client shall be entitled, but not obligated to procure such policy and recover the payments thereon from the Contractor either by withholding the amounts payable to the Contractor or otherwise. Any deviation from the same shall be subject to the prior written approval of the Client. The Client shall be entitled to prosecute and/ or compromise or settle the claims under such policies in such manner as may be deemed fit without reference to the Contractor. The Contractor shall provide necessary assistance to the Client in this regard.

(e) The Client, however reserves the right to take all or some of the insurance policies on its own and thereafter the Contractor shall be required to process the claims if any for settlement under the policies so taken by the Client. The Client further reserves its right to nominate an insurance company with whom the Contractor will be required to obtain the policies, insurance of Works, etc.

(f) Without limiting its obligations and responsibilities, the Contractor shall insure in the joint names of the Client and the Contractor against all loss or damage from whatever cause arising, for which it is responsible under the terms of the Contract and in such manner that the Client and Contractor are covered for the period stipulated in hereof, and are also covered during the Defects Liability Period.

(g) Such insurance shall be effected with an insurer and in terms approved by the Client which approval shall not be unreasonably withheld, and the Contractor shall, whenever required produce to the Client or its representative the policy or policies of insurance and the receipts for payment of the current premiums.

(h) The Contractor shall take out a Contractor's all risk insurance policy for the full amount of the Contract Price valid till the expiry of the Defects Liability Period, within 10 (ten) days of the date of issuance of the Letter of Award jointly in the name of the Client and the Contractor and the original policy shall be deposited with the Client.

(i) The Contractor shall similarly indemnify the Client against all claims, which may be made upon the Client, whether under the Workman's Compensation Act, 1923 or any Applicable Law in force during the currency of the Contract or at common land in respect of any employee of the Contractor or any Sub-Contractor and shall at its own expense effect and maintain up to the Defect Liability Period, with an approved office, a policy of insurance in the joint names of the Client and the Contractor against such risks and deposit such policy or policies with the Client from time to time during the currency of the Contract.

20.2. **Third Party Insurance**

(a) Before commencing the Works, the Contractor shall insure against loss for any material or physical damage, loss or injury which may occur to any property, including that of the Client, or to any person, including any employee of the Client, the Project Manager, other contractors/ Sub-Contractor(s) or their respective employees, agents, representatives and visitors, by or arising out of the completion of the Works or in the carrying out of the Contract.

(b) The Contractor shall, whenever required, produce to the Client or its representative the policy or policies of insurance and the receipts for payment of the current premiums.

(c) The term of such insurance shall be up to the end/ expiry of the Defect Liability Period and shall include for any damage to the properties and/ or injury including death to the persons of the general/ public/ architects and anyone else deemed to be third party.

20.3. **Provisions to indemnify Client**

The terms of such insurance shall include a provision whereby, in the event of any claim in respect of which the Contractor would be entitled to receive and indemnify under the policy being bought or made against the Client, the insurer will indemnify the Client against such claims and any cost, charges and expenses in respect thereof and the Contractor to indemnify the Client for any shortfall in the realization of the claims. The Client shall be entitled to set off any such amounts from the amounts due and payable by it to the Contractor under the terms of the Contract.

20.4. **Accident or Injury to workmen**

The Contractor shall be responsible and liable for or in respect of any damages or compensation payable at law in respect or in consequence of any accident or injury to any workman or other person in the employment of the Contractor or any Sub-Contractor. The Client shall not be liable for or in respect of any damages or compensation payable by law in respect or in consequence of any accident or injury to any workman or other person in the employment of the Contractor or any person working under/with the Contractor. The Contractor shall fully indemnify and keep indemnified the Client against all such damages and compensation, against all claims, proceedings, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

20.5. **Insurance against accident, etc., to workmen**

(a) The Contractor shall insure against such liability with an insurer approved by the Client, which approval shall not be unreasonably withheld, and shall continue such insurance during the whole of the time that any persons are employed by it on the Works and shall, when required, produce to the Client or its representative such policy of insurance and the receipt for payment of the current premium. Provided always that, in respect of any persons employed by any Sub-Contractor, the Contractor's obligation to insure as aforesaid under this sub-Clause shall be satisfied if the Sub-Contractor shall have issued against the liability in respect of such persons in such manner that the Client is indemnified under the policy, but the Contractor shall require such Sub-Contractor to produce to the Client or its representative, when required, such policy of insurance and the receipt for the payment of the current premium.

(b) Notwithstanding the requirements mentioned in the above, the Contractor shall at the minimum provide for Contractor's all risk insurance policy to cover the following:

(i) entire Contract Price for the period of completion including Defect Liability Period;

(ii) third party insurance to cover for any damages to third party. This shall be up to the end of the Defect Liability Period and shall include for any damage to the properties and/ or injury including death to the persons of the general/ public/ architects and anyone else deemed to be third party;

(iii) policy to cover Contractor's liability under Employee's Compensation Act 1923, Minimum Wages Act 1948, Contract Labour (Regulation and Abolition) Act 1970 and other Applicable Laws. This shall be for the period up to issue of the Final Acceptance Certificate, including the Defect Liability Period;

(iv) insurance cover against damage, theft or any other loss of all Materials and Contractor's Equipment brought to the Site; and

(v) the Contractor shall insure against all such liabilities and shall continue such insurance during the term of the Contract including Defect Liability Period. Premium for all insurance policies shall be paid and borne by the Contractor and shall not be reimbursable.

(c) These insurance certificates shall be executed and shall state that the policies cannot be surrendered for 10 (ten) days after written notice of the Client having consented to such surrender.

(d) The Contractor shall obtain written confirmation of similar certificates from all Sub-Contractors and thereby assume responsibility for any claims or losses to the Client resulting from failure of any of the Sub-Contractors to obtain adequate insurance protection in connection with the Works.

(e) If the Contractor fails to effect and keep in force the insurances referred to in Clause 20, or any other insurance which it may be required to effect under the terms of the Contract, then and in any such case the Client may effect and keep in force any such insurance and pay such premiums as may be necessary for that purpose and from time to time deduct the amount so paid by the Client as aforesaid from any monies due or which may become due to the Contractor, or recover the same as a debt due from the Contractor.

20.6. **Insurance for Contractor's Equipment**

(a) The Contractor shall insure the Contractor's Equipment against all loss or damage. This insurance shall cover loss or damage from any cause in so far as such insurance is readily obtainable. Such insurance shall be for a limit of not less than the full replacement value (including delivery to the Site). Such insurance shall be in such a manner that each item of Contractor's Equipment is insured while it is being transported to and from the Site or the right of way and throughout the period it is on or near the Site or the right of way.

(b) The Client shall have no liability for the loss/ damage to the Contractor's Equipment unless such loss or damage are due to reasons attributable to the Client.

(c) Client shall deduct from any amount due to the Contractor under the Contract entire insurance premium and other costs that the Client shall have paid to the insurer or incurred or may otherwise recover such amount as a debt due from the Contractor.

20.7. **Insurance for Contractor's Personnel**

The Contractor shall effect and maintain insurance against liability for claims, Contractor's Personnel damages, losses and expenses (including legal fees and expenses) arising from the death, injury, sickness or disease to any person employed by the Contractor or any Sub-Contractor of all types. The Client and the Client's representatives shall also be indemnified under the policy of insurance, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Client or of the Client's representative's personnel. For a Sub-Contractor's employees, such insurance may be effected by the Sub-Contractor, but the Contractor shall be responsible for compliance with this Clause.

20.8. **General Requirements for Insurance**

(a) The Contractor shall comply with the conditions stipulated in each of the insurance policies. The Contractor shall not make any adverse material alteration to the terms of any insurance without the prior approval of the Client.

(b) If the Contractor fails to effect and keep in force any of the insurance required wherever applicable under the Contract, or fails to provide satisfactory evidence policies and receipts in accordance with this sub-Clause, the Client may, without prejudice to any other right or remedy, effect insurance for the coverage relevant to such default, and pay the premiums due. Such payments shall be recoverable from the Party whose obligation it was to effect the insurance.

(c) Nothing in this Clause limits the obligations, liabilities or responsibilities of the Contractor, under the other terms of the Contract or otherwise. Any amounts not insured or not recovered from the insurers shall be borne by the Contractor in accordance with the Contract.

21. DEFECT LIABILITY PERIOD

21.1. **General** During the Defect Liability Period, the Contractor shall remain liable for any technical or other defects in the Works.

(a) The Defect Liability Period shall be [12 (twelve months)] from the issuance of the Take Over Certificate ("**Defect Liability Period**"). If the Contractor re-performs any of the Works or otherwise makes good

the Works (as the Client shall, at its discretion, determine) a defect in terms of this Clause 21.2, then the Defect Liability Period with respect to any such re-performed Works, or Works which have been otherwise made good, shall be a period of [12 (twelve) months] from the date of re-performance of such Works, or the date when such Works, have otherwise been made good, as the case may be. Provided that, the Defect Liability Period pursuant to this Clause 21.2 shall be subject to a maximum period of [30 (thirty) months] from the issuance of the Take Over Certificate. Provided further that, if the Contract is terminated prior to the issuance of the Take Over Certificate, then, the provisions of this Clause 21.2 with respect to the Defect Liability Period for repair, replacement, or otherwise making good shall apply *mutatis mutandis*, and in such an event the Defect Liability Period shall be [12 (twelve) months] from the date of termination.

(b) If during the Defect Liability Period, any defect is found in the design, construction, or engineering being part of the Works, of the New admin. & Engg. Block, the Contractor shall promptly and in any event no later than [3 (three) days] from the receipt of the notice from the Client in terms of Clause 21.2, commence the correction of any errors, omissions, defects or deficiencies in the Works, re-perform any part of the Works, or repair, replace or otherwise make good (as the Client shall, at its discretion, determine) such defect, in addition to any damage to the New admin. & Engg. Block caused by such deficiency in Works, at the sole risk and expense of the Contractor. Provided that, the Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the New admin. & Engg. Block arising out of or resulting from normal wear and tear.

(c) The Contractor shall perform all remedial action and re-perform any part of the Works required in such a manner and at such time, and shall co-ordinate its activities in connection therewith as notified by the Client in this regard.

(d) The Contractor shall in re-performing the Works or undertaking any repair/ replacement under this Clause 21, which could affect the safe and effective use of the New admin. & Engg. Block or any part thereof, observe all requirement of the Client and the Project Manager with regard to safe and effective use or operation thereof.

(e) During the Defect Liability Period¸ any re-design, repair or replacement of any part of the New admin. & Engg. Block requiring the New admin. & Engg. Block to be shut-down, shall be undertaken in co-ordination with Client so as to minimize disruption of the ongoing operations of the New admin. & Engg. Block. Such re-design, repair or replacement may, at Client's option, require Works to be carried out at the Site by the Contractor's personnel, beyond the normal working hours, including weekends and public holidays. All costs required for the performance of such re-design, repair or replacement shall be to the account of the Contractor.

(f) During the performance of the re-design, repair or replacement of any part of the New admin. & Engg. Block as provided in Clause 21.6, the Contractor shall procure that the Contractor's personnel act in compliance with Applicable Law, the Site regulations, work rules, workmen's compensation requirements as well as safety procedures.

21.2. **Notice of Defect**

The Client shall provide the Contractor a notice stating the nature of any defect in the New admin. & Engg. Block and/or Works, together with all available evidence, promptly following the discovery of such defect. The Client shall afford all reasonable opportunity to the Contractor to inspect any such defect. The Contractor shall, within 3 (three) days of the notice from the Client in this regard, submit to the Client details of the proposed re-performance of the Works and/or the repairs or replacements, which it proposes to make, the estimated duration of the repairs or the duration required to effect the replacement Works, details or parts of the New admin. & Engg. Block considered necessary to shut down and the

proposed dates for such re-performance, repairs or replacements. All Works and repairs and replacements shall be carried out at a time and for periods agreed with the Client pursuant to Clause 21.

21.3. **Access**

With regard to repairs or re-performance of Works needed, the Client shall afford the Contractor, subject to its reasonable security restrictions, the necessary access to the New admin. & Engg. Block and the Site to enable the Contractor to perform its obligations under this Clause 21.

21.4. **Tests**

(a) The Contractor shall carry out the tests, in relation to the repaired part of the New admin. & Engg. Block and shall endeavor not to disrupt the New admin. & Engg. Block as a whole, to demonstrate that such defect has been removed and that the repaired part of the New admin. & Engg. Block is functioning in the manner in which it is required to function under the Contract. Such tests shall be conducted, solely at its cost and expenses and the Contractor shall provide all materials, manpower, tools and tackles etc., which are required for carrying out the said tests.

(b) In addition to the tests conducted under Clause 21.10(a), if the repair or making good is of such a nature that it may affect the efficiency of the New admin. & Engg. Block or any part thereof, the Client shall provide the Contractor a notice of [28 (twenty eight) days] requiring additional tests to be conducted on the defective part of the New admin. & Engg. Block and the Contractor shall promptly, at its own risk and cost, carry out any such additional tests.

(c) If any part of the New admin. & Engg. Block fails the tests as set forth in Clause 21.10.(a), the Contractor shall carry out further repair, replacement or making good, as the case may be, until that part of the New admin. & Engg. Block passes such tests. The tests, in character, in no event shall be inferior to what has been agreed upon by the Client and the Contractor.

21.5. **Failure to Remedy Defects**

(a) If the Contractor fails to commence repair of the defect or any damage to the New admin. & Engg. Block caused by such defect, within the time frame stipulated in Clause 21.3, following the notice from the Client in this regard, the Client may, by notice to the Contractor, proceed to repair such defect.

(b) In addition to the Client's rights pursuant to Clause 21, if, in the reasonable opinion of the Client, a defect in the New admin. & Engg. Block or part thereof, is expected to cause serious loss or damage which can be prevented by immediate action, such defect may be corrected by the Client or a third party designated by the Client. Upon intimation by the Client in this regard, the Contractor shall assist wherever possible in undertaking any necessary corrections. Notwithstanding anything to the contrary stated in the Contract, any action undertaken by the Client pursuant to this Clause 21.11.(b), shall not in any way relieve the Contractor of its responsibilities under the Contract and the warranties set forth in Clause 18 and Clause 19 (Warranties) shall not be reduced or affected on account of the Client undertaking such action.

(c) All costs incurred by the Client in terms of this Clause 21.11.(a), shall be paid to the Client by the Contractor and/or may be deducted by the Client from any monies due to the Contractor and/or claimed by invoking the Performance Bank Guarantee. For the avoidance of doubt, it is clarified that any action undertaken by the Client in terms of this Clause 21.11 shall not extinguish the Contractor's liabilities arising pursuant to the terms and conditions of the Contract.

(d) If the Contractor fails to remedy the defect or damage under Clause 21.11, the Client shall have the right to:

(i) terminate the Contract pursuant to Clause 34 as a whole or in respect to such major part which cannot be put to the intended use and without prejudice to any other rights, under the Contract or otherwise, the Client shall then be entitled to recover all sums paid for the Works or for such part (as the case may be), the cost of dismantling the same and clearing the Site; or

(ii) accept the deficient New admin. & Engg. Block and proportionately reduce the Contract Price to reflect the diminished value to the Client and such reduction shall be determined by the Client at its discretion.

21.6. **Latent Defect**

(a) If, any defect appearing in any part of the Works, is of a kind that would not have been apparent to the eye prior to the expiry of the Defect Liability Period (a "**Latent Defect**") and arises within a period of [5 (five) years] from the Completion Date, the same shall be made good by the Contractor by repair or replacement. The Client shall, upon discovery of Latent Defect, notify the Contractor. The Contractor shall commence repair on such Latent Defect no later than [3 (three) days], or such other mutually agreed time period, from the receipt of a notice from the Client in this regard.

(b) The Contractor shall have the right to investigate the cause of any problem or abnormality in the New admin. & Engg. Block, which the Client reasonably believes is due to a Latent Defect.

(c) If the Contractor fails to commence repair of any Latent Defect within the time specified in Clause 21.12(a), following receipt of a notice from the Client, the Client may cause such repairs to be affected at the Contractor's expense.

21.7. **Serial Defect**

(a) If, during the Defect Liability Period, more than [15% (fifteen percent)] of the Works contains the same defect ("**Serial Defect**"), then a Serial Defect shall be deemed to exist in all such parts of the Works.

(b) If a Serial Defect exists, then it shall be deemed to be a defect for the purposes of this Clause 21.13 and all provisions with regard to the rectification of defects as set out in this Clause 21.13 shall apply *mutatis mutandis* to the rectification of the Serial Defect.

(c) Without prejudice and in addition to Clause 21.13(b), if a Serial Defect exists, the Contractor shall:

(i) promptly perform a thorough investigation to ascertain the cause of the Serial Defect and provide a report to the Client detailing the cause and effect of the Serial Defect;

(ii) subject to Clause 21.6, remedy all Works which are deemed to be effected by the Serial Defect including carrying out any necessary alterations, additions, modifications, design modifications, repairs or replacements regardless of whether a defect has made itself apparent in such parts of the Works at the time that the threshold stated under Clause 21.13(a) is exceeded.

21.8. **Costs, Taxes and Duties**

The Contractor shall be responsible for payment of all costs, taxes (including all indirect taxes except excise duty, entry tax and octroi and duties incurred in the course of performance of its obligations under this Clause 21.

22. VARIATIONS AND CHANGE IN CONTRACT ELEMENTS

22.1. **Introducing a Change**

The Client shall have the right to propose and subsequently require the Contractor, from time to time, till the issuance of the Take Over Certificate, to make a Change in accordance with the procedure set out in Clause 22.3 ("**Change**"). The Contractor shall execute and be bound by a Change proposed by the Client, unless the Contractor promptly provides a notice to the Client (along with supporting documents) that, the Change:

(a) will have an adverse impact on the achievement of the Performance Parameters; or

(b) comprises the omission of any Works which are to be carried out by a third party.

22.2. **No Change for Default**

No variation made on account of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such variation shall not result in any adjustment of the Contract Price or the postponement of the Completion Date.

22.3. **Changes Originating from Client**

(a) If the Client proposes a Change pursuant to Clause 22.1, it shall send to the Contractor, a notice ("**Request for Change Proposal**") requiring the Contractor to prepare and provide to the Project Manager within [15 (fifteen) days] of the Request for Change Proposal, a proposal ("**Change Proposal**") which shall include the following:

(i) brief description of the Change, including a description of the proposed corrective activities and/or Works to be executed or modified, and a programme for its execution, together with supporting calculations containing a break down for the actual cost of supplies for any items required/Works to be executed to give effect to the Change;

(ii) effect on the Completion Date and the necessary modifications;

(iii) the effects of implementation of the Change, taking into account the omission of execution of a portion of the Works, if any;

(iv) the cumulative impact of effects resulting from the stated Change on all prior Works and any changes in the Works to be executed as scheduled; and

(v) estimated cost of the Change;

(vi) effect of the Change on the safety of the New admin. & Engg. Block, if any; and

(vii) effect on any other provisions of the Contract.

(b) In addition to the information specified in this Clause 22.3(b), the Change Proposal shall include such other information as the Client may reasonably request in connection with each Change, and shall include copies of all price quotations and other documents as may enable the Client to verify the Contractor's proposed costs or savings in respect of the Change. For the avoidance of doubt, it is clarified that Contractor shall bear all costs and expenses in relation to the Change Proposal, whether or not such proposal is ultimately implemented.

(c) The pricing of a Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract as set out in Bidding Documents. If the rates and prices of any Change are not available in the Contract, the Parties shall agree on specific rates for the valuation of the Change. If the Contractor is instructed to proceed with a Change, prior to the determination of its value, the Contractor shall keep contemporary records of all labour hours, cost of Materials and Contractor's Equipment and any other cost related to undertaking the Change. Such records shall be provided to the Client upon request.

(d) If before or during the preparation of the Change Proposal, it becomes apparent that the aggregate effect of compliance with the Change and with previously issued Change Orders, would have the effect of increasing or decreasing the Contract Price as originally set forth by more than [15% (fifteen percent)], the Contractor shall provide a notice of objection prior to providing the Change Proposal. If the Client accepts the Contractor's objection, the Client and the Contractor shall agree on specific rates for the valuation of the Change and the Contractor shall submit the Change Proposal accordingly. If the Client does not accept the Contractor's objection, then the Client may cancel or vary the Request for Change Proposal, in which case, the Contractor shall submit the Change Proposal in accordance with the Client's revised Request for Change Proposal. However, in case of any Dispute in this regard, the matter may be resolved in terms of Clause 35 (Dispute Resolution).

(e) Upon receipt of the Change Proposal, the Client and the Contractor shall mutually agree upon all matters in the Change Proposal, including agreement on rates if such rates are not available in the Contract or if the limit of [15% (fifteen percent)] has been exceeded. Within 15 (fifteen) days of such agreement, the Client shall, if it intends to proceed with the Change, issue to the Contractor an order ("**Change Order**") whereby:

(i) the Client shall grant an extension of time, if necessary;

(ii) the agreed adjustments, if any, shall be made to the Contract Price and the Completion Date; and

(iii) such other changes may be ordered as may be required to give effect to the Change.

(f) The Client shall only instruct a Change under this Clause 22.3(f), upon mutual agreement with the Contractor on the quotation and the terms and conditions of the implementation of the Change.

(g) If the Client is unable to reach a decision within 15 (fifteen) days of the receipt of the Change Proposal, it shall notify the Contractor with details of the expected time by when the Contractor can expect a decision. For the avoidance of doubt, it is clarified that the Contractor shall continue to perform its obligations under the Contract, whilst awaiting a response from the Client in relation to the Change Proposal.

(h) If the Client decides not to proceed with the Change, for any reason whatsoever, it shall, within 30 (thirty) days from the receipt of the Change Proposal, or such later date indicated to the Contractor, notify the Contractor accordingly.

(i) If the Client and the Contractor cannot reach an agreement on:

(i) the price for the Change;

(ii) an equitable adjustment to the Completion Date; or

(iii) any other matters identified in the Change Proposal,

then, the Client has the right to instruct the Contractor to proceed with the Change by issuing an instruction in this regard ("**Pending Agreement Change Order**").

(j) Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Change under the Pending Agreement Change Order. The Parties shall thereafter attempt to reach an agreement on the outstanding issues under the Change Proposal. If the Parties cannot reach an agreement within 60 (sixty) days from the date of issuance of the Pending Agreement Change Order, then the matter may be resolved in terms of Clause 35 (Dispute Resolution).

22.4. **Changes Originating from Contractor**

(a) The Contractor shall have a right to propose a Change only, when in the Contractor's opinion, if adopted, such change would:

(i) accelerate Completion;

(ii) reduce the cost to the Client of constructing and developing the New admin. & Engg. Block;

(iii) improve the efficiency or value to the Client of the completed Works;

(iv) improve the quality, efficiency or safety of the New admin. & Engg. Block or any part thereof; or

(v) otherwise be of benefit to the Client,

in each instance, by submitting to the Client a written application in this regard, at its own cost and expense, giving reasons for the proposed Change and including the information stated in Clause 22.4 ("**Application for Change Proposal**").

(b) Without prejudice to the above, the Contractor shall, during the term of the Contract, have a continuing obligation to suggest to the Client for its consideration, Changes known to the Contractor, as may be necessary to incorporate significant new developments in technology which are applicable or appropriate for the New admin. & Engg. Block or any part thereof. If the Contractor proposes such a Change, it shall submit to the Client an Application for Change Proposal, *inter-alia*, identifying the benefits of such Change.

(c) Upon receipt of the Application for Change Proposal under this Clause 22.4., the provisions of Clauses 22.3(c) to 22.3(j) shall apply *mutatis mutandis*.

22.5. **Improvements**

The Client or the Contractor may propose changes in the Technical Specifications in respect of the New admin. & Engg. Block or quality thereof, which enhances the performance of the New admin. & Engg.

Block. If the Parties agree upon any such changes, the same shall be given effect to in accordance with the procedure specified in this Clause 22.

22.6. **Exclusions**

(a) Notwithstanding anything to the contrary, no Change Order shall be granted if:

(i) the Contractor seeks any Change or variation in its obligations which is due to any fault in the Documents supplied by it or due to any misrepresentation relating to any warranties provided by the Contractor;

(ii) the Change is necessary in order for the Contractor to satisfy its responsibility to complete the Works and ensure that the New admin. & Engg. Block is capable of performing as contemplated under the Contract and as specified in the Technical Specifications; or

(iii) the Change relates to the re-performance of any of the Works due to the Contractor's failure to comply with the Technical Specifications.

(b) Notwithstanding any other provision of the Contract, none of the following shall:

(i) be considered under any circumstances as a Change;

(ii) be taken into account when calculating the effect upon the Contract Price; or

(iii) by itself, be considered the basis for any adjustment of the Contract Price:

(A) any escalation in the cost of materials or labour; or

(B) any normal design improvements effected by the Contractor.

23. CONTRACT PRICE AND INVOICING

23.1. **Payment of Contract Price**

(a) The Contract Price is exclusive of service tax and works contract tax and the applicable taxes and duties shall be payable in accordance with the provisions of Clause 21.14 (Taxes and Duties).

23.2. **Mobilization Advance**

(a) 10% of Contract Value against an irrevocable bank guarantee as prescribed in the tender form for equivalent value and recoverable 12.5% basis from 2nd RA bills however 100% mobilization will be recovered once the value of work done reached of 80% of contract value.

23.3. **Escalation/Contract Price Variation**

Subject to the provisions of Clause 22 (Variation and Change in Contract Elements) and Contract Price, the Contract Price shall be firm till the completion of the obligations of the Contractor under the Contract and there shall be no escalation whatsoever of the Contract Price.

23.4. **Full and Complete Payment**

a) The Contract Price shall be the full and complete payment for satisfactory discharge of the Contractor's performance of its obligations under the Contract and all things necessary for the proper execution and completion of the Works and the remedying of any defects and except as otherwise provided, includes all costs necessary for the completion of the Works and compliance with the terms and provisions of the Contract.

b) For the avoidance of doubt, it is clarified that the Contract Price includes all Direct Taxes, direct, indirect and ancillary charges, cess, costs and expenses of whatsoever nature, including for the Contractor's Equipment & Materials, license, royalty and fees, accessories, Intellectual Property licenses and Documents to be provided under the Contract. The applicable indirect taxes shall be paid in accordance with Taxation.

24. TERMS OF PAYMENT

24.1. **General**

The Contract Price shall be paid in accordance with this Clause 24.

24.2. **Effect of Payment**

No payment of the Contract Price made by the Client, shall be deemed to constitute acceptance by the Client of the Works or any part(s) thereof and shall not relieve the Contractor of any of its obligations under the Contract.

24.3. **Currency of Contract Price**

All payments of the Contract Price shall be made by the Client to the Contractor in INR (Indian Rupees).

24.4. **Terms and Procedure of Payments of the Contract Price**

(a) The Contractor shall submit an invoice to the Client [in triplicate] by the 1st week of each month providing details of the achievement, in the immediately preceding month. The Invoices shall be accompanied with relevant supporting documents (including work completion reports to be submitted by the Contractor) and any relevant documents required by the Client in this regard. The Contractor shall submit to the Client, for its approval, a copy of each Invoice to be submitted by the Contractor pursuant to this Clause 24. The approval of the Client shall be made within 30 (Thirty) Days, (10 days to the PMC + 20 days to the Client) from the submission of such Invoice in a manner satisfactory to the Client. The proforma of the Invoice and the documents and details to accompany it shall be mutually discussed and agreed to by the Parties, provided that, the Contractor shall at all times ensure that Invoices are raised in accordance with the relevant provisions of Applicable Law, so as to enable the Client to avail credit of the taxes indicated in the said Invoice.

For the avoidance of doubt, it is clarified that if an Invoice is not accompanied by the supporting documents, then such amounts of the Invoice shall not be due and payable by the Client, until the supporting documents have been provided by the Contractor. Further, the withholding of any amounts by the Client pursuant to this Clause 24, shall not constitute an event of default for non-payment, on the part of the Client.

(b) If an amount under an Invoice is disputed for any reason by the Client in terms of Clause 24, or if the Invoice is not raised in accordance with the relevant provisions of Applicable Law, then such amounts of the Invoice shall not be due and payable by the Client and the Client shall be entitled to withhold payment of the amounts under such Invoice, which shall only be released upon the resolution of the Dispute in terms of Clause 35, or upon receipt of a revised Invoice raised in accordance with the relevant provisions of Applicable Law, from the Contractor, as the case may be. Further, the withholding of any amounts by the Client pursuant to this Clause 24 shall not constitute an event of default for non-payment, on the part of the Client. The Contractor shall provide details concerning the description of the Works executed and any further substantiation as Client may reasonably require, including any other information or documentation relating to the performance of the obligations of the Contractor under the Contract, that the Client might reasonably need to present, from time to time, to a Government Instrumentality.

(c) The Client shall, subject to Clause 24.4.(b), make payments of undisputed amounts under an Invoice, within 30 (Thirty Days) days following the approval by the Client of the Invoice pursuant to Clause 24. The Client shall pay amounts under each Invoice directly to such bank account(s) of the Contractor, as may be instructed by the Contractor to the Client.

(d) 5% (five percent) retention of the value of Works certified by the Project Manager, shall be made in every Invoice by the Client.

(e) It is expressly clarified that the value of the Retention Money shall not exceed 5% (five percent) of the Contract Price in aggregate and shall be retained by the Client till the expiry of the Defect Liability Period.

(f) The Retention Money shall be released by the Client, subject to the following conditions being satisfied:

(i) the Contractor has achieved Final Completion;

(ii) the New admin. & Engg. Block has been handed over to the Client in terms of Clause 11.4;

(iii) the Contractor has executed all the Works to the sole satisfaction of the Client;

(iv) the Defect Liability Period has expired, and the Contractor has rectified all defects in terms of Clause 21;

(v) the Contractor has paid all liquidated damages, indemnity sums and other payments due from the Contractor under this Agreement.

(vi) the Contractor has assigned to the Client or provided Client with all warranties or guarantees that Contractor has received from Sub-Contractors to the extent Contractor is obligated to do so pursuant to this Agreement.

(vii) all Contractor's Materials and other supplies, equipment, surplus, waste, huts, wreckage, debris, rubbish, and temporary facilities to which Client does not, and is not entitled to hold title, have been removed from the Site, and the Site have been restored in accordance with the terms of this Agreement provided that, all activities in relation to clearing and disposal shall be conducted in accordance with all Applicable Laws;

(viii) all the Contractor's Personnel and the personnel of the Sub-Contractors and their personnel, have been removed from the Site;

(ix) all Sub-Contractors have been paid their dues by the Contractor and Contractor has delivered the final release and waiver of Liens and claims pursuant to this Agreement and has delivered such other documents and certificates as Client has reasonably requested to ensure compliance with all Applicable Laws; and

(x) all activities required as per Applicable Law on account of the completion of the Works have been completed by the Contractor.

Provided that the Retention Money may be released upon submission an unconditional and irrevocable bank guarantee from a reputable bank acceptable to the Client for an amount equivalent to the Retention Money. The Retention Money Bank Guarantee shall be valid up to the expiry of the Defect Liability Period and shall have a claim period of 3 (three) months from the date of its expiry. If requested by the Client, the Contractor undertakes to extend the validity period of the Retention Money Bank Guarantee.

(g) The Client shall withhold from payments to be made to the Contractor and pay to the Governmental Authority, any and all taxes required to be withheld pursuant to Applicable Law. The Client shall provide to the Contractor the tax deduction certificates, for such withheld amounts.

(h) All Invoices shall be endorsed with the contract number and title.

(i) Payments made by the Client against any Invoice shall not preclude the right of the Client to thereafter dispute any items invoiced and paid for.

(j) Except as provided in Clause 24, if any other amounts are due and payable from one Party to the other, including payments pursuant to Clause 10 (Liquidated Damages) and Clause 28 (Indemnity), then the Party to whom such amounts are owed shall provide to the other Party an invoice accompanied by/along with the calculations and with the relevant documentary proof showing the basis for the calculations substantiating the claimed payments. The Party liable to make payment under a Miscellaneous Invoice shall make payment against the same within 30 (thirty) days from the date of receipt of such Miscellaneous Invoice.

(k) Notwithstanding the provisions of this Clause 24, the Parties shall have the right to dispute, in good faith, any invoiced item. Where any amount, under an Invoice or a Miscellaneous Invoice, as the case may be, is disputed by a Party, then such Party shall, within 21 (twenty one) days of receipt of the Invoice or Miscellaneous Invoice, as the case may be, notify the other Party of such Dispute and the Parties shall seek to resolve the Dispute by mutual consultation. If the Parties fail to resolve the Dispute by mutual consultation within 15 (fifteen) days of the date of such notice then the disputing Party shall withhold payment of such disputed amount till the resolution of such Dispute pursuant to Clause 35 (Dispute Resolution). Provided that, the disputing Party shall duly make payment of the undisputed amount in accordance with this Clause 24 (Terms of Payment).

(l) The Client shall withhold sums equivalent to taxes at applicable rates on the amount payable to the Contractor by way of consideration under the Contract in accordance with the provisions of the Income Tax Act, 1961, as amended or modified and applicable. The Client shall not make such withholdings in the event that the Contractor produces a certificate from the appropriate authority constituted under the Indian Income Tax laws to the effect that no withholding taxes would be required on the payments received by the Contractor from the Client.

(m) The Contractor shall adhere to the directions of the Client, Project Manager and/or the Architect, as the case may be in terms of the provisions laid down in the Contract.

24.5. **Client's Claims**

(a) If the Client considers itself to be entitled to any payment under any Clause of the Contract or otherwise in connection with the Contract, and/or to any extension of the Defect Liability Period in accordance with Clause 21, it shall, as soon as practicable after becoming aware of its claim or circumstances giving rise to such claim, provide the Contractor with notice and particulars of such claim. A notice relating to any extension of the Defect Liability Period shall be given before the expiry of such period.

(b) The notice for claim shall specify the provisions of the Contract which the Client relies upon or other basis of the claim, and shall include substantiation of the amount and/or extension to which the Client considers itself to be entitled in connection with the Contract. The Client shall then proceed to agree or determine (i) the amount (if any) which the Client is entitled to be paid by the Contractor, and/or (ii) the extension (if any) of the Defect Liability Period in accordance with Clause 21.

(c) The Client may deduct the amount due to it pursuant to such a claim from the Contractor, from any monies due, or that become due, to the Contractor or may issue a Miscellaneous Invoice with regard to such amounts.

25. SITE OFFICES, SECURITY AND FACILITIES

25.1. The Contractor shall supply and erect a well-lit, temporary Site office for use by it at its own cost, if required. The layout of the Site office, Drawing shall be as approved by the Client in consultation with the Project Manager. The Site office shall contain wash rooms, seating arrangement with furniture and good ventilation.

25.2. A fully furnished Site office to be provided to the Client and the Project Manager for total 10 (TEN) members crew for a period of 90 days beyond actual project completion date. The Site office to contain workstations, meeting/conference room, manager cabin, air conditioning, grid ceiling, chairs, flooring, washrooms, maintenance of wash rooms/office, tea and drinking water facility, projector, projector screen, walky talky, fridge, dining area, safety PPE (safety helmet, google, shoes (with steel toes), reflective vest, public address system, for the Client and Project Manager and their visitors.

25.3. No photos/CCTV shall be installed by the Contractor without prior written permission from the Client.

25.4. The Contractor shall deploy Site security team for material storage as well as for manpower movement at Site till the Take Over Certificate is issued by the Client. The Contractor security team should work closely with the Client and the Project Manager for maintaining the Site logistics.

26. SAFETY REQUIREMENTS

26.1. The Contractor shall comply with the safety precautions, protective measures, housekeeping requirements, etc. as set out in **Section 10**. The Client shall have the right to stop the work at Site, if in its opinion, proceeding with the Works will lead to an unsafe and dangerous condition. The Contractor shall get the unsafe condition removed or provide protective equipment. The Contractor shall ensure that all workmen are aware about the nature of risk involved in their work and have adequate knowledge for carrying out their work safely.

26.2. The instructions issued by the Client and/or the Project Manager pursuant to the Contract are indicative and not exhaustive. Therefore, the Contractor shall be responsible to ensure that adequate safety measures are adopted in the course of execution of the Works in accordance with the Contract in accordance with safety standards / statutory regulations, as applicable.

26.3. In case of any non-compliance by the Contractor of any of the provisions of this Clause 26 above would, without prejudice to any other remedy that the Client may be entitled to under Applicable Law or in the Contract or otherwise, the Client shall be entitled to impose an amount as compensation in its sole discretion.

27. LIMITATION OF LIABILITY

27.1. The total liability of the Contractor to the Client under or in connection with the Contract, shall not exceed the Contract Price, provided that, this limitation shall not apply to any obligation of the Contractor to:

(a) pay liquidated damages to the Client in accordance with Clause 10;

(b) indemnify the Client in accordance with the provisions of the Contract;

(c) pay the indemnity amount that may be payable under Clause 28.2; or

(d) pay for losses caused due to the Contractor's gross negligence, fraud or willful misconduct.

27.2. **No Consequential Loss**

Notwithstanding anything to the contrary, except in cases of payment to be made pursuant to Clause 27.1., neither the Contractor nor the Client shall be liable to the other, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that, this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Client.

28. INDEMNITY

28.1. **General:** The Contractor shall protect, defend, indemnify and hold the Client, and their directors, key managerial personnel, employees, agents and representatives harmless from and against:

(a) any and all losses, damages, costs, expenses (collectively "**Losses**") incurred by reason of the acts or omissions of the Contractor, its officers, directors, employees, in the performance of the Contract or execution of Works, including without limitation any and all Losses, arising directly or indirectly from or incurred by reason of any failure of the Contractor or any Sub-Contractor (i) to pay any taxes, duties, cesses etc. required to be paid by such person, (ii) to make any payments in respect of taxes, duties, cesses which are to be paid by such person in connection with the performance of its obligations relating to the Contract, (iii) any such Losses arising from injury to or death of third parties or damage to or loss of property of third parties;

(b) any and all Losses, incurred by reason of or arising from claims or sanctions or penalties imposed by any Governmental Authorities or others for any actual or asserted failure by the Contractor, Sub-Contractor(s) or any of their respective officers, directors, employees to comply with any Applicable Laws;

(c) any and all Losses, arising directly or indirectly from or incurred by reason of the Works being undertaken at the Site post Completion Date;

(d) any damage caused by the Contractor to the Site;

(e) all Contractor and/or Sub-Contractor employee claims, failure of Contractor or its Sub Contractors to comply with Applicable Law and Prudent Industry Practices and liability for any hazardous substances claims; and

(f) any and all Losses, arising directly or indirectly as a result of any violation of any patents, design rights, trademark or copyright, confidentiality and other protected rights arising in connection with the Contractor's Equipment or in the course of the completion of the Works; and

(g) any and all Losses, damages, costs, expenses, claims, demands, proceedings, or liability however arising against or incurred by the Client relating to the Project due to or arising from or contributed to by any act, omission or default on the part of the Contractor.

28.2. **Zero Fatality Rate at Site**

(a) The Contractor acknowledges that having a zero fatality rate at the Site is important for the Client and a material requirement of the Safety Requirement. If the Contractor does not take all safety precautions and/or fails to comply with the Safety requirement or the Applicable Laws for the safety at the Site while performing its obligations under the Contract, then without prejudice to the provisions of Clause 28.1 or any other obligation of the Contractor under the Contract, the Contractor shall pay to the Client:

(i) a sum of [INR 10,00,000 (Rupees ten lakh only)] in case of death of any workman/employee at the Site; and

(ii) a sum of [INR 2,50,000 (Rupees two lakh fifty thousand only)] in case of permanent disability of any workman/employee at the Site,

in each case occurring during the course of the Contract.

(b) The Contractor shall pay such amounts to the Client, immediately upon a demand being made for the same, but in no event later than the time period prescribed in Clause 24.4.(g) for payment of a Miscellaneous Invoice. The Parties agree that such amounts received by the Client from the Contractor shall be paid by the Client to the family of such deceased workman/employee or such disabled workman/employee. The compensation mentioned in this Clause 28.2. is in addition to the compensation payable to the workman under the relevant provisions of the Employee's Compensation Act, 1923 and rules framed there under or any other Applicable Law.

28.3. **Proceedings**

On receipt of any notice of any claim from any third Party, which would entitle any Party ("**Indemnified Party**") to claim indemnification from the other Party ("**Indemnifying Party**"), the Indemnified Party shall within a reasonable time provide a written notice of the same to the Indemnifying Party along with all the documents available with it in respect of the said claim specifying in detail the claim, the amount claimed by the third Party, the date on which the claim arose and the nature of the default to which such item is related (including a reference to the applicable provision of the Contract). The Indemnifying Party shall be entitled to but not obliged to participate in and control the defense of any such suit, action or proceeding at its own expense or direct the Indemnified Party to defend such claim, at the cost of the Indemnifying Party. If the Indemnifying Party elects to control the defense of any such suit, action or proceeding, the Indemnified Party shall render all necessary assistance including grant of access to premises and personnel and to relevant documents and records that it possesses or controls to the extent required by the relevant

adjudicatory authorities or is necessary for the purposes of investigating the matter and enabling the Indemnifying Party to take the action referred to in this clause. The Indemnifying Party may also request the Indemnified Party, at the cost of the Indemnifying Party to dispute, resist, appeal, compromise, defend, remedy or mitigate the matter or enforce against the Third Party the Indemnifying Party's rights in relation to the matter and in connection with proceedings related to the matter or use reputable advisers and lawyers chosen by the Indemnifying Party. The Indemnified Party shall not settle any such suit, action or proceeding without the prior written consent of the Indemnifying Party.

28.4. **Payment of Indemnities**

Where a Party is entitled to payment from the other Party pursuant to this Clause 28, such Party shall promptly notify the other Party of the same and issue a Miscellaneous Invoice. The other Party shall make payment of such Miscellaneous Invoice in accordance with Clause 24.4.(g).

29. CONFIDENTIAL INFORMATION

29.1. Each Party shall treat as confidential, the other Party's information consisting of specifications, designs, plans, drawings, software, data, prototypes, or other business and/or technical information, methodologies, know-how, processes, quotations, which such party discloses to the other party ("**Information**").

29.2. Each Party agrees that for a confidentiality period beginning on the date of execution of the Contract and ending 2 (two) years from the termination of the Contract, the receiving Party shall use information only for the purpose of the Contract ("**Purpose**"), shall hold information in confidence using the same degree of care as it normally exercises to protect its own proprietary information, but not less than reasonable care, taking into account the nature of the information, and shall grant access to Information only to its employees who have a need to know, shall reproduce Information only to the extent essential to fulfilling the purpose, and shall prevent disclosure of information to third parties. The receiving Party may, however, disclose the Information to its consultants and contractors with a need to know; provided that by doing so, the receiving Party agrees to bind those consultants and contractors to terms at least as restrictive as those stated herein, advise them of their obligations, and indemnify the disclosing party for any breach of those obligations.

29.3. Upon the disclosing Party's request, the receiving Party shall either return to the disclosing Party all Information or shall certify to the disclosing Party that all media containing Information have been destroyed.

29.4. The foregoing restrictions on each Party's use or disclosure of Information shall not apply to information that the receiving Party can demonstrate:

(a) was independently developed by or for the receiving Party without reference to the information, or was received without restrictions; or

(b) has become generally available to the public without breach of confidentiality obligations of the receiving Party; or

(c) was in the receiving Party's possession without restriction or was known by the receiving party without restriction at the time of disclosure; or

(d) is required to be disclosed pursuant to legal or administrative requirement for disclosure; provided that the receiving Party has given the disclosing Party prompt notice of such demand for disclosure and the receiving Party reasonably cooperates with the disclosing Party's efforts to secure an appropriate protective order.

30. INTELLECTUAL PROPERTY RIGHTS

30.1. All designs, Drawings, specifications, data, Documents, reports, studies, manuals, programs, analyses and all other items produced by the Contractor or the Sub-Contractors or the suppliers in the performance of the Works (herein collectively referred to as the "**Work Product**"), shall become and remain the property of the Client, and the Contractor shall deliver the same (properly sorted and indexed) to the Client in accordance with the provisions of the Contract and in any event upon termination of the Contract. For the avoidance of doubt, the Parties acknowledge and agree that the Drawings and plans, and all ELECTRICAL AND ELV and construction plans and Drawings relating to the Project, are the Client's property.

30.2. The Contractor hereby irrevocably assigns to the Client any rights it may have or acquire in (and waives and will require each supplier, vendor and Sub-Contractor to waive all "moral rights" it may have with respect to) any and all such Work Product.

30.3. The Contractor shall save harmless and indemnify the Client from and against all claims and proceedings for or on account of infringement of any intellectual property rights including patent rights, designed trademark or name or other protected rights in respect of any constructional plant, technology, design, machine work, or Material used for or in connection with the Works or any of them and from and against all claims, proceedings, damages, cost, charges and expenses whatsoever in respect thereof or in relation thereto. Except where otherwise specified, the Contractor shall pay all tonnage and other royalties, rent and other payments or compensation, if any, for any document/materials required for the Works.

30.4. **Ownership of Documents**

All Documents and other documents prepared by the Contractor and used in the performance of the Works shall be the property (including all intellectual property rights vested in the documents prepared by the Contractor for the purposes of the development of the New admin. & Engg. Block) of the Client. The Contractor shall supply to the Client all such Documents and other documents, as well as any drawings, specifications, calculations, memoranda, data, notes and other materials at the earlier of Final Acceptance or termination of the Contract. The Client shall have the right to copy, use, transfer and communicate the documents for the purposes of completing, operating, maintaining, altering, adjusting, or repairing the New admin. & Engg. Block.

30.5. **Use of Drawings by Contractor**

The Contractor shall be entitled to retain a reproducible set of all Drawings and Documents and other documents delivered to the Client by the Contractor in accordance with the Contract. Provided that the Contractor shall not at any given point of time use the information provided in such documents or such documents for any purpose other than the completion of the Works.

30.6. **Royalties and License Fees**

The Contractor shall pay all required royalties and license fees with respect to proprietary rights, intellectual property licenses and agreements and shall procure (at its cost), as required, the appropriate proprietary rights, intellectual property licenses and agreements for materials, methods, processes and systems in accordance with the provisions of the Contract. The Contractor shall not incorporate any materials, methods, processes or systems that involve the use of any Confidential Information, intellectual property or proprietary rights that the Client does not have the right to use or that may result in claims or suits against the Client or the Contractor arising out of claims of infringement of any domestic or foreign patent rights, copyrights or other proprietary rights, or applications for any such rights, or use of Confidential Information.

31. FORCE MAJEURE

31.1. Except as otherwise specifically provided in the Contract, neither Party shall be liable to the other Party or be deemed to be in breach of the Contract by reason of any delay in performing or observing, or any failure to perform or observe, any of its obligations under the Contract, if the delay or failure was due to any event or circumstance which is not within the reasonable control, of the Party, and with the exercise of due diligence, was not reasonably foreseeable and could not reasonably be prevented, avoided or removed by such party ("**Affected Party**") through the exercise of reasonable skill or care, and does not result from the Affected Party's negligence or the negligence of its agents, employees or Sub-Contractors, which causes the Affected Party to be delayed, in whole or in part, or unable to partially or wholly perform its obligations under the Contract ("**Force Majeure Event**"). Force Majeure Event shall include:

(a) acts of God, fire, flood, lightning, storm, typhoon, hurricane, tornado, earthquake, epidemics, or other natural disaster;

(b) act of Government Authority which makes the performance of obligations under the Contract to be impossible for either Party;

(c) event of war (whether declared or not), invasion, act of foreign enemy, hostilities, revolution, rebellion, terrorism, insurrection, military, usurped power, mutiny or civil war.

For the avoidance of doubt, it is clarified that insufficiency of finances or funds or any obligation for the payment of money or the Contract becoming onerous to perform shall not be a Force Majeure Event.

31.2. The Affected Party shall give notice to the other Parties of any Force Majeure Event as soon as practicable, but not later than 7 (seven) days after the date on which such Party becomes aware of the occurrence of the Force Majeure Event or should reasonably have known of the commencement of the Force Majeure Event. If an event of Force Majeure results in a breakdown of communications rendering it unreasonable to give notice within the applicable time limit specified herein, then the Affected Party shall give such notice as soon as reasonably practicable after reinstatement of communications, but not later than 1 (one) day after such reinstatement.

31.3. The notice of occurrence of a Force Majeure Event shall be a pre-condition to the Affected Party's entitlement to claim relief under the Contract. Such notice shall include full particulars of the event of Force Majeure, its effects on the Party claiming relief and the remedial measures proposed. The Affected Party shall give the other Party regular reports on the progress of those remedial measures and such other information as the other Party may reasonably request about the Force Majeure Event.

31.4. The Affected Party shall give notice to the other Parties of:

(a) the cessation of the relevant Force Majeure Event; or

(b) the cessation of the effects of such Force Majeure Event, on the performance of its obligations under the Contract.

31.5. To the extent not prevented by a Force Majeure Event pursuant to Clause 31, the Affected Party shall continue to perform its obligations under the Contract. The Affected Party shall use its reasonable efforts to mitigate the effect of any Force Majeure Event as soon as practicable.

31.6. Subject to Clause 31.3, the Affected Party shall not be responsible or liable for failure to perform its obligations under the Contract, if such failure is due to a continuing Force Majeure Event, provided that a Force Majeure Event shall not release the Affected Party of its obligations to perform the other obligations, which are unaffected by such Force Majeure Event.

31.7. For avoidance of doubt, no Party's obligation to make payments of money due or payable prior to occurrence of the Force Majeure Events under the Contract shall be suspended or excused due to the occurrence of a Force Majeure Event in respect of such Party.

32. CHANGE IN LAW

32.1. For the purpose of the Contract, the term "**Change in Law**" shall mean the occurrence of any of the following events after the Execution Date, resulting into any increase or decrease in the Contract Price:

(a) the enactment, coming into effect, adoption, promulgation, amendment, modification or repeal (without re-enactment or consolidation) in India, of any Applicable Law, including rules and regulations framed pursuant to such Applicable Law;

(b) a change in the interpretation of any Applicable Law by any Government Authority having the legal power to interpret or apply such Applicable Law;

(c) the imposition of a requirement, for obtaining any applicable approvals/licenses/ permits which were not required earlier;

(d) a change in the terms and conditions prescribed for obtaining any approvals/licenses/ permits required by a Party for the performance of its obligations under the Contract or the inclusion of any new terms or conditions for obtaining such approvals/licenses/ permits;

(e) any change in tax or introduction of any tax made applicable for performance of the Works as per the terms of the Contract.

For the avoidance of doubt, it is clarified that any revision to the Contract Price or the Completion Date would be restricted to direct transactions between the Parties.

32.2. If the Contractor is affected by an incident of Change in Law and considers itself eligible for relief for such Change in Law, then, it shall give notice to the Client and the Project Manager of such Change in Law, along with the documentary evidence, if any, establishing the impact of such Change in Law. The notice served pursuant to this Clause 32 shall provide, amongst other things, precise details of:

(a) the Change in Law;

(b) effect on the Contractor;

(c) adjustment required in the Contract Price.

32.3. If after the date of issuance of the Letter of Award, there is a Change in Law, due to which the Completion Date needs to be changed, the same shall be revised reasonably in accordance with Clause 7.2, to the extent that Contractor has thereby been affected in the performance of any of its obligations under the Contract.

32.4. If the Parties fail to agree upon a revision to the Contract Price, the matter shall be referred to an internationally recognized firm of auditors, mutually acceptable to the Parties. If the Parties cannot agree on a firm of auditors, then the Client shall appoint an internationally recognized firm of auditors. The said firm of auditors, shall within 10 (ten) days of such appointment, make a determination as to such proposed revision, which determination shall be binding on the Parties.

33. SUSPENSION

33.1. **Suspension of works:**

The Contractor confirms and acknowledges that the Client shall have the right to, by giving a 1 (one) day prior written notice to the Contractor, with the previous approval of the Client, direct the Contractor to suspend the progress of the Works or any part thereof for such time and in such manner as the Client may consider necessary and shall during such suspension require the Contractor to properly protect and secure the Works, so far as is necessary in the opinion of the Client. The extra cost incurred by the Contractor in giving effect to the instructions of the Client under this Clause shall be borne by the Client unless such suspension is:

(a) otherwise provided for in the Contract, or

(b) necessary by reason of some default on the part of the Contractor, or

(c) necessary by reason of climatic conditions on Site, or

(d) necessary for the proper completion of the Works or for the safety of the Works or any part thereof in so far as such necessity does not arise from any act or default by the Project Manager or the Client.

Provided that the Contractor shall not be entitled to recover any such extra cost unless it gives written notice of its intention to claim such costs to the Client and the Project Manager within 15 (fifteen) days of the order of the Client. The Client shall settle and determine any extra payment and/or extension of time under to be made to the Contractor in respect of such claim in accordance with the provisions of the Contract.

33.2. **Suspension of Work**

The Contractor shall, on the instructions of the Client and/or the Project Manager, suspend the progress of the Works or any part thereof for such time and in such manner as the Client and/or the Project Manager may consider necessary and shall, during such suspension, properly protect and secure the Works or such part thereof so far as is necessary in the opinion of the Client and/or the Project Manager.

33.3. The Project Manager shall after due consultation with the Client and the Contractor, determine any extension of time to which the Contractor is entitled on account of such suspension.

34. TERMINATION

34.1. The Contract may be terminated by the Client by issuing a written notice of 7 (seven) days to the other Parties upon occurrence of the any of the following events:

(a) any breach of the terms of the Contract and/or Applicable Law which breach has not been rectified by the Contractor within 7 (seven) days of issuance of notice by the Client; or

(b) if the Contractor fails to complete the Works by the Completion Date.

34.2. The Client shall have the right to terminate the Contract forthwith if the Contractor becomes insolvent or an order is made or a resolution passed for the liquidation, administration, winding-up, bankruptcy or dissolution of the other Party (otherwise than for the purposes of a solvent amalgamation or reconstruction) or an administrative or other receiver, manager, trustee, liquidator, administrator, insolvency resolution professional or similar officer is appointed over all or any substantial part of the

assets of the Contractor or the Contractor enters into or proposes any composition or arrangement with its creditors generally or anything analogous to the foregoing occurs in any applicable jurisdiction.

34.3. Expiry or termination of the Contract shall not relieve the Parties of their obligations due up to the time of such expiry or termination, nor shall such expiry or termination prejudice any claim of either Party that has already accrued prior to such expiry or termination.

34.4. If the Client elects to terminate the Contract pursuant to Clause 34, the Client shall be entitled (but not obliged) to complete the remaining Works either by itself or by any other contractor on account of and at the risk and cost of the Contractor. If the Client decides to complete the remaining Works, it shall be entitled to recover the cost and other charges associated with such completion from the Contractor. In all cases, and irrespective of whether the Client decides to complete the remaining Works, the Client shall be entitled to recover all costs, expenses or losses flowing from the termination from the Contractor.

34.5. The Contractor shall, at Client's request and at Contractor's cost and expense, perform the following services in relation to the Works so affected:

(a) cease all further Works which is the subject of the termination, except such Works as Client may specify in the termination notice for the sole purpose of protecting that part of the Works already executed;

(b) assist the Client in preparing an inventory of all equipment in use or in storage at the Site;

(c) assign to the Client or to any replacement contractor designated by Client, without any right to compensation, title to all Works not already owned by Client, together will all subcontracts and other contractual arrangements (including warranties) as may be designated by Client, all of which subcontracts and contractual arrangement shall be so assignable and assign to Client;

(d) remove from the Site all such Contractor's equipment and materials and waste material as the Client may request; and

(e) deliver to Client all design and other information in the possession of the Contractor as may be requested by Client for the completion of the Works.

34.6. The Parties agree that in the event of termination of the Contract, the Client shall pay to the Contractor the Contract Price proportionate to the Works completed by the Contractor to the Client's satisfaction by the date of termination.

35. GOVERNING LAW AND DISPUTE RESOLUTION

35.1. The Contract including all questions concerning the construction, validity and interpretation of the Contract will be governed by the laws of India. Subject to Clause 35.2 below, the courts at Gautam Buddh Nagar, Uttar Pradesh, India shall have exclusive jurisdiction on any matter arising under the Contract.

35.2. The Parties shall amicably resolve by mutual discussions any and all controversy, claim, differences or disputes arising out of or in connection with the Contract including any question regarding its existence, validity, invalidity, breach or termination ("**Dispute**"), failing which the Disputes shall be settled by arbitration in accordance with provisions of the Indian Arbitration and Conciliation Act, 1996. The arbitral tribunal shall consist of 1 (one) arbitrator. The seat for arbitration shall be Gautam Buddh Nagar, Uttar Pradesh, India and the language for arbitration shall be English. Any arbitral award shall be final and binding on the Parties.

35.3. The Contract and the rights and obligations of the Parties contained in the Contract shall remain in full force and effect pending issuance of the award in such arbitration proceedings, which award, if appropriate, shall determine whether and when any termination shall become effective.

36. **MISCELLANEOUS**

36.1. **Notices**

Any notice and other communications provided for in the Contract shall be in writing and shall be transmitted by e-mail or registered post or courier service in the manner as elected by the Party giving such notice to the following addresses:

In the case of notices to the Client:
Attn: [__]
Add: [__]
Email: [__]

In the case of notices to the Project Manager:
Attn: [__]
Add: [__]
Email: [__]

In the case of notices to the Contractor:
Attn: [__]
Add: [__]
Email: [__]

Any Party may, from time to time, change its address or representative for receipt of notices provided for in the Contract by giving to the other prior written notice.

36.2. **Waiver**

Waiver by a Party of any default by the other Party(ies) in the observance and performance of any provision of or obligations under the Contract:

(a) shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions or obligations under the Contract;

(b) shall not be effective unless it is in writing and executed by a duly authorised representative of such Party;

(c) shall not affect the validity or enforceability of the Contract in any manner.

Neither the failure by a Party to insist on any occasion upon the performance of the terms, conditions and provisions of the Contractor any obligation hereunder nor time or other indulgence granted by a Party to the other Party shall be treated or deemed as waiver/breach of any terms, conditions or provisions of the Contract.

36.3. **Survival**

Termination of the Contract (a) shall not relieve the Parties of any obligations already incurred hereunder which expressly or by implication survives termination hereof, and (b) shall not relieve a Party of any

obligations or liabilities for loss or damage to the other Party(ies) arising out of or caused by acts or omissions of such Party prior to the effectiveness of such termination or arising out of such termination.

36.4. **Partial Invalidity**

If any provision of the Contract is held to be invalid or unenforceable to any extent, the remainder of the Contract shall not be affected thereby, and each provision of the Contract shall be valid and enforceable to the fullest extent permitted by applicable law. Any invalid or unenforceable provision of the Contract shall be replaced with a provision which is valid and enforceable and most nearly reflects the original intent of the unenforceable provision.

36.5. **Amendments**

Subject to the terms of the Contract, no modification or amendment to the Contract shall be valid or binding unless made in writing and duly executed by all the Parties.

36.6. **Cost**

Except as otherwise provided in the Contract, each Party will bear its own costs and expenses incurred in connection with the preparation and execution of the Contract and for performance of transactions contemplated hereunder including any accounting, tax, legal and other advisors' expenses and expenses.

36.7. **Further Assurances**

Each Party will, at its own respective cost and expense, execute and do (or procure to be executed and done by any other necessary party) all such deeds, documents, acts and things as may be required from time to time or as may be necessary to give full effect to the Contract or for performance of its obligations under the Contract or for compliance with the provisions of Applicable Law.

36.8. **No Partnerships**

Nothing contained or implied in the Contract shall constitute or be deemed to constitute a partnership or agency between the Parties and none of the Parties hereto will have any authority to bind, commit or make any representations on behalf of the other Party(ies).

36.9. **Anti-Corruption**

(a) The Parties shall not, and shall ensure that their respective Affiliates, officers, agents, directors and representatives shall not, in the course of conduct of performance of their obligations under the Contract: (i) the (Indian) Prevention of Corruption Act, 1988, or any other applicable anti-bribery or anti-corruption laws under any Applicable Law; or (ii) offer, pay, promise to pay, or authorize the payment of any money, or offer, give, promise to give, or authorize the giving of anything of value, to anyone, including Public Officials, either directly or indirectly, to improperly influence official action or obtain an improper advantage. This includes acting through a third party under circumstances where the Parties (or their respective Affiliates, officers, agents, directors and representatives) know, or are aware of circumstance that may cause a significant risk, that all or a portion of such money or thing of value would be offered, given or promised to anyone, including a Public Official, for the purpose of:

(i) improperly influencing any act or decision of such Public Official in his official capacity;

(ii) inducing such Public Official to do or omit to do any act in relation to his lawful duty;

(iii) securing any improper advantage; or

(iv) inducing such Public Official to influence or affect any act or decision of any Government Authority;

(v) (any such payment, a "**Prohibited Payment**"), provided that Clause 36.9 shall not apply to any payment that is permitted by Applicable Law.

(b) For the purposes of this Clause 36, the term "**Public Official**" means any officer or employee of a government, public entity or public international organization (including any department, or agency thereof or any government-owned or controlled entity including state-owned enterprises), or any person acting in an official capacity for or on behalf of a government or public international organization.

Each of the Parties shall, and shall procure that each of their respective Affiliates, officers, agents, directors and representatives shall, promptly report to the other Party any Prohibited Payment of which they obtain knowledge, become aware of, or which they have reasonable grounds to believe has occurred during the term of the Contract.

37. Priority of Documents

The documents forming the contract are to be taken as mutually explanatory of one another, for the purpose of interpretation, the priority of the documents shall be in accordance with the following sequence:

a. The contract Agreement
b. The Letter of Intent
c. The Letter of Tender
d. GCC
e. Schedule of quantities and rates
f. The specifications
g. The Drawings
h. The schedules and any other documents forming part of the Contract.

SECTION: 5

FISCAL ASPECTS

SCHEDULE OF FISCAL ASPECTS

Description	**Schedule of Fiscal Aspects.**
Location Of work	Engineering & Admin Block Project at Galgotias University, Yamuna Expressway, Greater Noida, Uttar Pradesh
Scope of Work	Main Scope: The detailed Scope for execution shall conform to the BOQ, Technical specification and drawings for the HVAC + CHILLER & BMS works. This Contract is re measurable Item rate contract and all the scope as per the drawings/tender/attached annexure shall be included. The quoted rates hold firm for the entire work plus the period up to the settlement of final bill. No escalation will be entertained towards labor, materials, petrol, diesel and or any such account.
Type of Contract	Item rate & Re-measurable type of contract.
Escalation	This is a fixed price contract with all rates being firm till completion of project and no escalation is admissible on any item, for any reason.
Date of Commencement	Immediate from the date of issuance of LOI/Work Order.
Contract Construction Period	Commencement of work: Immediate from the date of issuance of LOI. Total time for the completion of all works under the scope of this contract and handover shall be 10 (Ten) Calendar months form the date of issuance of LOI including final handing over and de-snagging. Contractor shall submit a detailed Construction programme in the form of bar-chart for major milestones along with resource loading.
Mobilization Advance	10% of Contract Value against an irrevocable bank guarantee as prescribed in the tender form for equivalent value and recoverable 12.5% basis from 2nd RA bills however 100% mobilization will be recovered once the value of work done reached of 80% of contract value.
Payment cycle	The owner, after submission of bill from Contractor and recommendation from the Project Manager, shall pay 100% of the bill amount to the Contractor. This payment shall be released within 30 (Thirty) working days (10 days for PMC + 20 Days for client) from the date of application for payment from Contractor; if the Project Manager disputes any items shown on the application for payment or the Owner disputes on the certificate for payment, the Project

	Manager shall bring the disputed items to the attention of the Contractor, and within said time period, the Owner shall pay the amount of such application for payment that is not in dispute.
Payment terms	The Terms of payment shall be as follows: - 10% against submission of shop drawings on Pro-rata basis 50% against supply on Pro-rata basis 15% against installation on pro-rata basis 15% against testing and commissioning at site on pro-rata basis 10% after handing over the work.
Amount of Liquidated Damage	Time is the essence of the contract. If the works are not completed within 10 months' time, liquidated damages of 1% of the Contract Value per week will be deducted, subject to a maximum of 5% of the contract value, after which the contract can be terminated at the option of M/s. Galgotias University, Plot No 2, Sector 17A, Yamuna Expressway, Opp Budha International Circuit, Greater Noida, Uttar Pradesh – 203201.
Defects Liability Period	12 months from the date of issuance of Final Completion Certificate.
Performance Guarantee	5% of the Accepted Contract Amount, within 7 days of issue of Agreement, and shall be released upon successful completion of Defect Liability Period.
Performance Bonus	If works completed within 10 (Ten) calendar months form the date of issuance of LOI, bonus of 1% of the contract value will give to the contractor
Percentage of retention	5% from each certified or an unconditional, irrevocable and divisible bank guarantee from any nationalized bank of the equal amount. 50% retention money shall be released upon the issuance of final completion certificate against unconditional, irrevocable and divisible bank guarantee from any nationalized bank of the same amount and balance 50% shall be released at the end of Defect Liability Period.
Bank Guarantees	The bank guarantees required to be submitted by the successful contractor shall be as per the forms and formats provided by Client. Only bank guarantees drawn from nationalized banks shall be accepted
Insurance	The contractor will take Contractors All Risk Insurance (CAR) Policy in our joint name for the full contract value together with the value of material supplied by M/s. Galgotias University, Plot No 2, Sector 17A, Yamuna Expressway, Opp. Budha International Circuit, Greater Noida, Uttar Pradesh – 203201 In addition to the above you should also take • Workmen Compensation Insurance for your direct workmen and your subcontractor's Labour. • Group Personnel Accident Insurance to your staff. • Third party liability insurance.

	Personal Injury: You will take insurance policy for a value as may be required subject to an individual limit of Rs.1.00 lakh per person per incident
Price for Extra Items	The accepted rates in the schedule of quantities will apply for the entire project. Any item of work which is not covered in the schedule of quantities shall be paid as per the actual cost of materials, Labour, 2% (will be towards tools, cartage, power, and water) and 15% (towards all overheads and profits), provided the same cannot be derived from quoted rates from similar comparable items. It is to be clearly understood that claims for extras of any nature will not be entertained unless such extras are duly authorized by project manager in advance
Taxes & Duties	The rate shall include all customs duties and Excise Duties, taxes, like sales tax any other direct or indirect taxes (if applicable) works contract tax, GST, entry tax etc. There shall be no extras on any account whatsoever, excluding the statutory variations after award of contract.
ESI and PF	The accepted rates are inclusive of ESI and PF as applicable
Statutory Compliance of State & Central Government and Local Municipal Authorities	Following Statutory compliance obligations shall be performed during the entire Contract period without any failure. I. Labour License II. Provident Fund & ESI III.GST VI. Other compliances changes from time to time as per State and Central Government.
Construction Related Statutory Compliances	Shall be arranged by the Contractor at no additional cost to the Client.
Construction Water	Construction Water will be provided by the client free of cost at one point, the contractor must make his own arrangements for distribution at the site at his own cost.
Construction Electricity	There will be a charge for electricity provided by the client, and the contractor will install a sub-meter to measure the amount of electricity consumed. The contractor is responsible for making his own arrangements for the supply and distribution of electricity as part of the work that he is undertaking. The Contractor shall be responsible for ensuring that uninterrupted power supply is provided for their works by installing silent DG sets at their own expense as required.
Safety, Health, and Environment	Contractor shall adhere to all Health and Safety standards as issued by the Bureau of Indian Standards, National Building Code, 1983 as required by Project Management Consultant / Owner regulations of local Authorities.
Labour	Adequate number of persons to the satisfaction of the Project Manger shall be provided. Statutory requirements of EPF, ESIC and all other applicable Labour legislations to be complied with; and monthly certification to that effect to be submitted.

	Duty allocation and Roaster control shall be contractor's responsibility
Sanitary	The Contractor shall make all arrangements till completion of Project for sanitary and storm sewer arrangements as required and shall make all necessary payments directly to appropriate departments. The Contractor shall arrange to provide the Contractor's subcontractor, these facilities at no additional cost to the owner.
Contractors Conditions	Apart from those stated in the above provisions, no other conditions of the Contractors shall be acceptable
Storage, Safe Custody & Protection of Finished items	Rent free space will be provided at the site. The cost of construction of store, security etc. will have to be arranged by the contractor
RA Bills	The RA bill in triplicate shall be submitted by 1st week of every month to the Project Manager along with all supporting documents. Only one bill per 30 days shall be admitted. Bill/Invoice submitted by the contractor shall be strictly as per the format prescribed by the Project Manager. Bills will not be accepted/ received by the Project Managers if bills are not in the correct format as prescribed by the Project Managers or are not presented along with material invoices/ delivery challans, measurement sheets, rate analysis etc. The final bill shall be accompanied with all necessary and relevant handover/closure documents.
Final Bill	Within 45 days of Final completion of works and submission of handing over documents duly signed by the Architect/Project Manager/Client.
Correctness of Measurement.	In case measurements submitted with bills are found to contain incorrect information, the bill would be returned and would be admissible only with the next bill after correction of all measurements. The correct information shall be as per defined norms of measurement or generally accepted practices; any queries shall be discussed and clarified during project pre-Commencement meeting.
Weekly meetings/Monthly Meeting	The Project Manager will hold and preside over weekly progress meetings at the site. The scheduling of such meetings will be arranged by the Project Manager in advance or set up on a regular basis at a set time. Senior Management of Contractor shall be part of Monthly meeting arranged by Project Manager.
Billing Address/Shipping Address	M/s. Galgotias University, Plot No 2, Sector 17A, Yamuna Expressway, Opp Budha International Circuit, Greater Noida, Uttar Pradesh – 203201

SECTION: 6
SPECIAL CONDITIONS OF CONTRACTS

SPECIAL CONDITIONS OF CONTRACT

1.1 GENERAL INFORMATION

The Special / Particular Instruction and Conditions of Contract as described in this document are intended to amplify the General conditions of Contract and shall be read in conjunction with specifications of work, drawings and all other documents forming part of this Contract wherever the context so requires. The following clauses shall be considered as an extension and not in limitation of obligation of the Contractor.

All expenses incurred by the CONTRACTOR in connection with obtaining information for submitting this tender including his visits to the site or efforts in compiling the tender shall be borne by the CONTRACTOR and no claims for reimbursement shall be entertained.

Not withstanding the sub-division of the documents into separate sections and volumes every part of each shall be deemed to be supplementary to and complementary of every other part and shall be read with and into the CONTRACT.

Wherever it is mentioned in the specification, that the CONTRACTOR shall perform certain work or provide certain facilities, it is understood that the CONTRACTOR shall do so at his own cost.

1.2 OBLIGATION OF CONTRACTOR

The obligation of Contractor in fulfilment of HVAC works are stated below:

- Checking the design data, HVAC heat loads & system proposed in the tender & drawings by Consultants and confirming adequacy of the system or highlighting the deficiency / shortfall & possible ammendments / solutions. This process should be carried out first during the tender / bidding stage and finally during preparation of shop drawings / Good For Construction drawings / during submission of technical submittals, but before finalization of equipment order on sub-contractors / sub-vendors / suppliers and before supply & installation of equipment / system so that any changes required in the equipment / system can be done timely. Contractor/ Vendor to work out its own Basement ventilation, smoke venting & Staircase / Lift well / Lift Lobby pressurization calculation to check its suitability / adequacy as per latest 'NBC' of India & Fire safety norms / codes / fire NOC. Contractor to comment on any inadequacies & propose alternative solution. This should also be done first during tendering process and finally after obtaining order but before execution.
- Procurement, fabrication and supply
- Inspection and testing
- Expediting and co-ordinating with other agencies
- Scheduling and Monitoring
- Training the Client's representative in the Operation & Maintenance of the Plant

- Erection, checking and testing
- Commissioning of the equipment & complete system.
- Carrying out performance tests to meet the specification requirement and to the full satisfaction of EMPLOYER
- Providing Guarantee - Performance as well as product / equipment guarantee.
- Maintenance during Guarantee/Defects Liability period
- Final documentation

Checking up the equipment and other materials to ensure that the same are as per the specifications laid down in description of work and drawings and also to make sure that they are in proper condition to be taken up for erection.

Drawing up a detailed time schedule and organise the erection work in conformity with the time schedule.

Arranging for the procurement and ensuring availability at the site at the required time of all the erection tools, necessary tackle, required for the erection work such as cranes, air compressor, welding sets, oxy-acetylene cutters, electric and pneumatic drills, steel wedges for levelling and grouting, scaffolding gay wire testing and cleaning equipment and all other construction equipment necessary for proper erection.

Arranging for procurement and ensuring availability at site at the time of all consumable construct materials for erection work such as welding electrodes, oxygen, acetylene and other welding gases, greases, petrol, cotton waste and all temporary fastening such as tack bolts clips, cleats and other materials, chemicals for cleaning and such other materials as may be needed to execute the handling and erection works.

Engaging and allotting an adequate number of engineers, erectors of all the required categories (Supervisory, skilled and unskilled labour) for carrying out different items at different stages of the erection work.

Assembling and installing of all items of machinery / equipment at their proper places at the plant site. The erection work will cover necessary operations such as, handling, sorting, stacking, unpacking, cleaning, assembling, bottling welding riveting, erecting, site fabrication, instrument cable laying and jointing, earthing, erecting, site fabrication, instrument cable laying and jointing, earthing, treatment for underground pipe protection, painting, thermal insulation and manual / mechanical / chemical cleaning, testing and other operations, provision of inserts, embedded plates in walls / roof / floor for erection of ducting, piping etc. Installation of all instruments – measuring and controlling of the plant. All control wiring also forms part of erection work.

Checking up of each individual items of plant equipment and also each pipeline, to ensure that the erection of these items has been properly carried out in conformity with the technical specification.

After all the installation and assembly work is completed the entire plant assembly including the pipe lines shall be checked up, by proper tests applicable to ensure that individual items of equipment, including pipe line have been properly installed.

Machines like compressors, pumps shall be checked up by actual working to satisfy that their alignment has been properly made and there are no mechanical faults.

Pipe lines shall be checked up by hydraulic tests to make sure that all valves, flanges etc., have been properly fitted up to that there are no leakages or wrong connection of interconnecting valves, pipes etc. Similarly all ductwork shall be tested to ensure that air leakages rates are within the limits prescribed in the specification.

Instruments shall be checked up individually to make sure that they are in proper working order. The testing shall be in accordance with INDIAN STANDARDS or accepted International Standards. All instruments used for testing and measurements shall be calibrated instruments acceptable to National level standards.

The performance of the aforesaid services should confirm strictly to the ENGINEER'S technical specification, which forms an integral part of 'THIS CONTRACT'.

It is only after the entire plant assembly has been thoroughly checked up on the lines indicated above and found satisfactory that erection work shall deemed to be completed and the plant considered READY FOR COMMISSIONING.

Plant and equipment details shall also be prominently displayed in engraved plastic nameplates.

The Contractor shall if called upon, also furnish necessary electrical wiring diagram to meet the requirements of the Electricity authorities.

1.3 QUALITY ASSURANCE REQUIREMENTS

GENERAL

Quality Assurance (QA) requirements form an integral part of the contract and all contractors are required to comply.

SCOPE

The scope of QA requirements is as follows:

a) Preparation of a Quality Assurance Plan by the Contractor, which is referred to as "CONTRACTOR'S QUALITY PLAN" or CQP.

b) Performance of:

- Quality Assurance (QA) and

- Quality Control (QC) activities at site

c) Documentation of the above

1.4 **TENDER DRAWINGS**

The Drawings issued with this Specification are for guidance of the CONTRACTOR and show the approximate positions of all items of equipment, etc. The actual and final position of all items of equipment shall be determined at site and approved by the Consulting ENGINEER. CONTRACTOR is to ensure that their proposal will meet with all the current rules and regulations of the relevant authorities in India.

1.5 **SHOP DRAWINGS**

a) All Shop Drawings shall be on Standard A0/A1 size paper depending upon the content and details of the drawing.

b) Before any work is put in hand, the Contractor shall submit two (2) sets of dimensioned Drawings showing all details of the equipment, piping, wiring and materials etc. to be used, to the Consulting ENGINEER for review. The Contractor shall not commence final connection works until the Drawings are reviewed by the Consulting ENGINEER.

c) Review of Drawings by the Consulting ENGINEER does not exonerate the Contractor from any responsibility under the Contract terms and conditions.

d) The detailed Shop Drawings, prepared at a minimum scale of 1:100, plus necessary detail plans and cross sections at a scale of 1:50, showing complete detail of each item of specially fabricated equipment shall be submitted to the Consulting ENGINEER for his review before proceeding with fabrication. These Drawings shall be based upon the floor plans and the following specifications. These Drawings shall include accurately dimensioned details and locations of any special wall openings that are required where items of equipment extend through walls.

e) If early review is required, the Contractor shall advise the Consulting ENGINEER to this effect when submitting the drawings.

f) The Contractor shall forward eight (4) sets of the reviewed shop drawings to the Consulting engineer for distribution to interested parties.

1.6 **WORKING DRAWINGS**

The Contractor shall at all times maintain on site, in good order and condition, a complete set of all Drawings and Documents necessary for the proper execution and checking of the Works. These Drawings and Documents shall be made available on request to the Consulting ENGINEER or other authorized persons on site. Any amendment shall be indicated on the Drawing, dated and signed by the Authorised person in charge, with reasons stated if possible.

1.7 **AS-INSTALLED DRAWINGS**

a) The Contractor shall prepare two (2) sets of paper prints of the As-Installed Drawings, diagrams and schedules as in the opinion of the Consulting engineers, shows an accurate record of the work as installed by the Contractor and submit to the Consulting ENGINEER for approval. When approved, the Contractor shall submit three (3) sets of paper prints, one (1) set of sepia and one (1) CD ROM of the approved As-Installed Drawings for reference and record by the Consulting ENGINEER.

b) Such records shall include the preparation of properly dimensioned drawings showing the following:

i) General arrangement of all services
ii) Cable routes, types of fixings, layout, support and other particulars;
iii) The detailed layout of all equipment, plant chambers, etc;
iv) Conduit runs, pipe runs, duct work, etc.
v) A system diagram giving means of identification, circuit labelling and mounting level of equipment, etc., provided under the Sub-Contract;
vi) Schedules of all equipment installed.

c) All Drawings submitted by the Contractor shall have in the bottom right hand corner in addition to the Contractor's name, title, scale, date and drawing number, the title of the project and subject of the drawings.

d) The retention sum or final payment will not be released until all such drawings and records have been received and approved by the Consulting ENGINEER.

e) One copy of the schematic drawing, isometric or layout drawing showing all equipment, controls, connections, etc. shall be framed and hung in the relevant Plant Room or location as directed by the Consulting ENGINEER.

1.8 **TESTING AND COMMISSIONING**

a) **GENERAL**

Testing shall mean providing that all of the systems efficiently meet the performance specified while in operation. The systems shall be tested in the presence of the Consulting ENGINEER who requires at least two full working days prior notice to enable him to attend.

The Contractor shall arrange for representatives of any of his own sub-Contractor to be in attendance.

It shall be the responsibility of the Contractor to supply all necessary testing equipment including pitot tube and manometer, anemometer, newly calibrated pressure gauge, etc. Provision of all testing equipment and the appropriately skilled labour shall have been included in the Tender Price.

Should anyone of the tests reveal a fault, the Consulting ENGINEER will order that the fault be corrected and re-tested prior to acceptance. All fees connected with testing of equipment payable by Contractor to any of the relevant Government Authority shall be borne by the Contractor.

b) COMMISSIONING TEST

i) The complete installation or any part thereof shall be tested, both before and after being commissioned to check the performance in operation. All fees connected with testing of equipment payable by the Contractor to any of the relevant Government Authority or expert from the Supplier shall have been included in the Tender Sum.

ii) The contractor shall be represented by a competent person approved by the Consulting ENGINEER during the whole of the period required for the tests.

iii) All materials and equipment supplied or erected under this Contract which fail the tests shall be replaced or rectified at once by the Contractor without cost to the EMPLOYER.

iv) The Contractor shall supply all necessary instruments, apparatus, connections, skilled and unskilled labour required for the tests to be conducted in the presence of the Consulting ENGINEERS, make accurate records of all tests carried out and furnish the Consulting ENGINEERS with four (4) COPIES OF THE Test Certificates and Schedule of Test Results in approved form.

v) The Contractor shall prepare a detailed and comprehensive checklist for use during commissioning and testing. The Contractor shall submit to the Consulting ENGINEER his proposed check list for approval as follow:

1) Ensure that all items that should be checked are included.
2) Produce a permanent record of the commissioning checks carried out.
3) Accordingly, the checklist must be built from information contained in the Specification, from Suppliers, SUB-Contractor's and Contractor's installation and commissioning similar equipment and systems.
4) The detail of the checklist must be such that it can be completed with a reading or a tick, which means that every device listed, has been checked.

1.9 **OPERATING MANUALS**

The Contractor shall prepare three (3) copies of an operating manual, in a stiff-covered ring binder two (2) for the EMPLOYER and one (1) for the Consulting ENGINEER, describing the operation and maintenance of the whole system and including: -

a) Operating instruction for all equipment
b) Catalogues for all equipment.
c) List of spares recommended;
d) Schedule of Recommended Maintenance.

Practical completion will be certified after the receipt of the above operating manual by the Consulting ENGINEER.

1.10 **IDENTIFICATION AND LABELLING**

Parts of the Works shall be properly labelled and identified. The contractor shall carry out the following work: -

i) Machine engraved traffolyte nameplates shall be provided to identify majority of equipment. Similar labels will indicate the function of ancillary equipment such as gauges, control valves, switches, indicating lights, push buttons, relays and other indicating devices.

ii) Lettering shall be black on white background. Nameplates for major items of equipment shall be engraved in lettering of at least 6 mm. Labels identifying ancillary equipment shall be engraved in lettering of at least 3 mm.

iii) Identification lettering shall be applied to all pipe work and to all conduit at the following spacing: -

1) For all concealed runs in walls or ceiling spaces, every 5 metres but at least once.

2) For exposed runs, every 10 metres but at least once for each exposed section.

The identification shall consist of stencilled painted black lettering 25 mm high naming the services.

1.11 PLANT OPERATION

The EMPLOYER shall have free and unrestricted use of the Contract Works or any part thereof which the Consulting ENGINEER may deem suitable without any interference whatsoever from the Contractor and such use by the EMPLOYER shall not relieve the Contractor of any liabilities or obligations in regard to the Contract.

1.12 TESTING

Routine and type for various items of equipment shall be performed at the SUB-Contractor's works and test certificates shall be furnished. The EMPLOYER or his authorised representative reserves the right to be present during the tests.

After notification to the EMPLOYER that the installation has been completed, the Contractor shall make under the direction of EMPLOYER such tests and inspections as have been specified or as the EMPLOYER shall consider necessary to determine whether or not the full intent of the specifications have been fulfilled and whether further tests shall be considered necessary. The Contractor shall bear all the expenses thereof.

The Contractor shall operate, test and adjust all air-conditioning, ventilation and exhaust system units, fan motors, all air handling appliances provided in connection with the installation and shall make all necessary adjustments and corrections thereof including the adjustments of all regulating dampers. A carefully detailed record of the results of these adjustments shall be furnished to and be subject to the approval of the EMPLOYER.

1.13 PERFORMANCE TEST

A performance test by keeping the plant running for a period of 72 hrs. shall be carried out in peak summer, peak monsoon and peak winter periods. During the tests all necessary readings shall be taken hourly. From the readings so taken, the Contractor shall also establish the plant capacity. The computed results shall tally with the specified capacities furnished with Tender.

The contractor shall install in the system temperature probes, flow meters, pressure gauges etc., to verify the capacity of the various equipment.

All the test equipment instruments, labour, operating personnel, oil and refrigerant required for these tests shall be furnished by the Contractor at his own cost.

If the test do not show satisfactory result, the Contractor shall at his own cost, rectify / replace and defective installation or part thereof as directed by the EMPLOYER within two months. The decision of the EMPLOYER shall be final and binding in this respect. Only after all these tests are satisfactorily completed and the defects found during these are rectified, the plant will be finally accepted.

1.14 **TESTING GUARANTEE**

All equipment and space conditions shall be tested after carrying out necessary adjustments and balancing to establish the equipment ratings and indoor space conditions. At least four sets of readings shall be taken daily for each item tested and submitted in the form shown separately. Instruments required for testing shall be furnished by the Contractor.

All equipment shall be guaranteed for the specified ratings with a tolerance of 0% on the minus (negative) side.

All equipments and the entire installation shall be guaranteed against defective materials and workmanship for a period of 12(twelve) months from the date the equipment and installation are handed over.

1.15 **REPORTS**

Provide 3 copies of the complete balancing and testing reports to the EMPLOYER / Consulting engineer. Report shall be neatly typed and bound suitable for a permanent record. Report forms shall contain complete test data and equipment data as specified.

1.16 **TRAINING**

Upon commissioning and final handover of the installation, the Contractor shall submit 3 copies of operating instructions, maintenance and service manuals, part lists and all final drawings and diagrams, indexed and bound together in hard cover ring binder.

The Contractor shall conduct a training programme for designated Employer's personnel. These courses shall be carried out during normal office hours. The date of commencement of training shall be mutually agreed upon and in any case shall be within two weeks of handover of installation.

The training programme shall cover all operating and maintenance aspects of the system, inclusive of detailed explanation and demonstration of each and every piece of equipment and an overview of the system network.

The training programme shall consist of both handouts and classroom training at the job site or at location agreed upon by the EMPLOYER.

All instruction manuals, tools, transportation, etc. association with the training programme shall be provided by the Contractor. Such cost shall be deemed to have been included in the CONTRACTOR programme.

1.17 **GUARANTEE**

The Contractor shall guarantee the inside conditions as stipulated elsewhere. In addition, the Contractor shall also guarantee that all equipment shall be free from any defect due to the defective materials and bad workmanship and that the equipment shall operate satisfactorily and the performance and efficiencies of the equipment shall be not less than the guarantee values.

The guarantee shall be valid for a period of 12 months after taking over and any parts found defective shall be replaced free of all costs by Contractor. The services of successful Contractor's personnel if requisitioned by the EMPLOYER during this defects liability period for such work shall be made available free of any cost.

The Contractor shall without any extra cost carry out for a period of 12 (twelve) months after the installation is taken over, all routine and special maintenance of the plant and attend to the defects that may arise in the operations of the plant.

Maintenance will consist of monthly maintenance and necessary adjustment and lubrication of the equipment by the Contractor's employee under competent direction and supervision. In addition to the monthly maintenance, special examination between regular intervals and emergency minor adjustment, call back services should be provided during the guarantee period.

Parts that become necessary due to normal wear and tear during the guarantee period will have to be replaced free of cost.

In case of any defect or malfunctions of the equipment during the period of maintenance, immediate attention must be ensured without claim to any extra amount, charges or compensation.

All the maintenance work will be performed during regular hours of regular working days. However the works in condenser coil and cleaning of cooling coils etc., should be carried out only during the holidays with prior permission from the EMPLOYER.

One month before the end of the defects liability period, the Contractor shall notify the EMPLOYER of the required inspections for all equipment and facilities including specific energy consumption.

1.18 **MAINTENANCE IN WARRANTY PERIOD**

The CONTRACTOR shall furnish warranty for the entire system for a defect liability period (DLP) of twelve (12) months after the final official hand over date of the installation duly approved by the consultants and project managers. This period shall include maintenance replacement of parts, regular periodic visit by qualified personnel of the CONTRACTOR and attending to emergency call at short notice.

1.19 **CONCLUSION OF 12-MONTH WARRANTY PERIOD**

Just before the expiry of the warranty period of the Contract, the Contractor shall carry out a complete system operability test on all the systems or sub-systems as called for in the Contract.

The purpose of the test is to verify that the performance of all the systems of sub-systems in the Contract is in accordance to the specifications.

All tests shall be carried out in the presence of the EMPLOYER or his representative.

The warranty period is deemed to be over if the EMPLOYER or his representative is completely satisfied with the system performance during the test.

1.20 **ANNUAL MAINTENANCE CONTRACT**

The CONTRACTOR shall quote separately for comprehensive and all-inclusive (labour and material and everything) Annual Maintenance Contract for full five years period after the Defect Liability Period (DLP). The CONTRACTOR shall bear the full responsibility for all kinds of maintenance which includes periodic maintenance as well as attending to all breakdown and emergency calls at short notice whenever called. During this five-year period the scope of annual maintenance contract includes repair and replacement of any or all parts as required. Besides, the replenishment of all consumables shall also to be included in the scope of annual maintenance contract.

The CONTRACTOR shall furnish the list of recommended spares along with quantity and unit price schedule to the EMPLOYER along with the bid. The EMPLOYER reserves the right the required spares during the tenure or on completion of annual maintenance contract at the quoted price which should be valid for the entire maintenance period i.e. five (5) years after DLP.

1.21 **COMPENSATION FOR SHORTFALL IN CONTRACT RATINGS.**

RATINGS / CAPACITIES OF THE PLANT

There shall be no credit to the CONTRACTOR if the output of the plant is higher than the rated capacity. There will be zero percent (0%) tolerance for the rated capacity on the negative sides.

During performance tests in case of any shortfall in the contracted system / equipment capacity, the Contractor will be given a chance to make adjustments after which the Performance test will be conducted again at the Contractors expense. In case the equipment does not meet the contract rating the equipment will have to be replaced at the cost of the Contractor within a reasonable period of time as will be indicated by the EMPLOYER and as per Performance as Guaranteed in the Tender.

1.22 **TAKING OVER CERTIFICATE**

As soon as the Works have been completed in accordance with the Contract and have passed the tests on completion, the Consulting ENGINEER will issue a provisional certificate (hereinafter called the

provisional Taking over Certificate) in which he shall certify the date on which the Works have been successfully commissioned.

1.23 **BRAND NAME / MAKE OF EQUIPMENT**

For the main air-conditioning plant, Contractors are required to offer only the 'Brand' Make / as indicated elsewhere in the specification of to ensure fair evaluation of proposal. It is to be noted by the contractor that materials / equipment, for which brand / make has not been specified, the contractor shall use only reputed makes. The contractor shall submit a list of such brands / makes to the consulting engineer along with his offer for approval.

1.24 **SITE MANAGER & SITE ENGINEER**

The site engineer posted at site shall have adequate experience for handling a job of this magnitude. The resume of the site engineer shall be submitted to the Consulting engineer for approval along with the offer.

1.25 Consumable materials during construction, commissioning testing and subsequent warranty period

The Contractor shall supply at his own cost the following consumable materials as and when required.

(a) Complete water requirements including system requirements as well as water required for testing and commissioning.

(b) All oils and greases required for lubrication of compressors, fan bearings, motors bearings, pivots and other moving parts.

(c) All refrigerant required to replace refrigerant losses in the refrigerant systems.

(d) All consumable, filter elements / rolls.

(e) All Chemicals for the correct chemical treatment of the chilled water system.

(f) All carbon brushes required to replace worn brushers in electric motors.

(g) All electric contact points required to replace worn electric contact points in switchgears, motor starter gears, electronic control gears and electric relays.

(h) All electric fuses required to replace blown fuses.

(i) All cotton waste, soap detergent and other cleaning materials required for cleaning purpose.

The cost of these consumable materials shall be included in the contract Price.

After every inspection and service, the Contractor shall submit a written report to the EMPLOYER with a carbon copy extended to the Architect.

1.26 PAINTING & LABELLING

GENERAL

Unless otherwise specified, all exposed surfaces including trucking and cable tray, ductwork, equipment, etc., shall be thoroughly cleaned and painted.

All ferrous metal surfaces without protective finishes shall be painted, except surfaces of moving parts, which shall be thoroughly oiled and greased as required.

Non-ferrous surfaces may be left unpainted unless called for in this specification or required by the Architect for the purposes of colour coding and identification. Aluminium grilles and diffusers shall be powder coated with colour approved by the architects.

All bare surfaces requiring painting shall first be given a priming coat followed by an undercoat and two finishing coats.

SIGN WRITING

All major items of equipment shall be identified with approved names and / or numbers of suitable size in proportion to the size of the respective items.

Pipelines shall be painted in contrasting colour directional arrows adjacent connections, valves and branches and at intervals of not more than 2.5 mm. These arrows shall be 75 mm long on pipes up to 50 mm diameter and 150 mm long on pipes over 50 mm diameter.

All stop valves and control valves the function of which are not obvious shall be provided with a non-corroding metal or laminated plastic identification tag. The tag shall indicate the service, and the area or items, which the valve serves.

1.27 CONTROL OF NOISE & VIBRATION

This section of the specification covers the supply, delivery, installation and testing of Noise and Vibration Control equipment to be used in the isolation of the various Mechanical equipment as called for in this specification.

It is the intent of this specification that noise levels due to mechanical equipment and related services will be controlled to the design objectives stated herein, in all occupied areas. The requirements specified are considered to be the minimum precautions necessary to achieve these objectives. The entire installation shall operate without objectionable noise and vibration as determined by the Architect.

The contractor shall examine all drawings and specifications including architectural and structural sets of working documents, before commencing any work on the project and shall immediately bring to the Architect’s attention any characteristics or properties of the building or any other factors which, in his opinion, would jeopardize or nullify the attainment of the design objectives.

The contractor shall guarantee that the complete plant and installation when operated within the design criteria shall acoustically perform to the noise criteria ratings specified.

The screw Chiller package shall be mounted on steel springs in series with neoprene. Limit stops are required to limit travel when machine is drained. A steel base frame suitable for point loading of the Chillers shall be provided as approved by the Architect.

MISCELLANEOUS EQUIPMENT

All equipment located above or under occupied areas and capable of producing noise or vibration shall be isolated from the structure.

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SECTION: 7
TECHNICAL SPECIFICATION

A. HVAC SYSTEM

GALGOTIAS UNIVERSITY

TECHNICAL SPECIFICATIONS

SUBHEAD-A. PUMPS & VARIABLE SPEED PUMPING SYSTEM

A. PUMPS:

1. SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of water pumps conforming to these Specifications and in accordance with requirements of Schedule of Quantities.

2. TYPE

The type and size of all chilled water, condenser water, hot water and condensate drain pumps for air conditioning applications shall be in accordance with requirement of Drawings and Schedule of Quantities.

3. CAPACITY

Water flow rates and head of the pumps shall be in accordance with the requirements of Schedule of Quantities or as may be required as per site conditions.

4. TRUE BACK PULL OUT DESIGN, END SUCTION, FLEXIBLE COUPLED PUMP:

"True Back Pull Out Design" End suction vertical split flexible coupled with tangential flow design volute for better efficiency, coupled with IE2/IE3/IE4 efficient motor as specified in the BOQ, spacer coupling, OSHA compliant coupling guard, in CI Casing Construction & Bronze fitted Impeller construction, specifically designed for quiet operation for chilled water cooling systems as indicated on the drawings.

- Pump shall be suitable for a standard operation at 175 PSIG, 12 BAR, PN12 of working pressure upto 250°F temperature. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.
- The bearing assembly shall be of High Strength Steel shaft. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
- Pump volute shall be of a cast iron design for heating systems (or cast bronze for normal water systems) with integrally cast pedestal volute support, with integral cast iron flanges drilled for 125# ANSI companion flanges. Volute shall be suitable for standard operation at 175 PSIG, 12 BAR, PN12 of working pressure upto 250°F temperature and are 250# flange drilled. Volute shall include gauge ports at nozzles, and vent and drain ports.
- Higher working pressure pumps of rating PN16 or PN20 may be required if called for in the schedule of quantities.
- Pumps with overhung volute shall not be acceptable
- Pump Curve should be continuously rising from High flow to zero Flow, drooping curves are not acceptable.
- Specially Designed Motors: Shall meet IE2/IE3/IE4 efficiency as specified in the BOQ & scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative.
- End suction pump has to be "Back Pull-Out" Truly defined; the statement should indicate ease of service and disassembly of the pump for service. Specifically, the bearing frame and impeller should be able to be removed for service without disturbing the pump volute or motor assembly. This capability substantially reduces pump downtime and decreases maintenance costs.

- CONDITION MONITORING SYSTEM: Continuously measures vibration and temperature at the outboard bearing and automatically indicates when pre-set levels of vibration and temperature have been exceeded, so that changes can be made before failure occurs. A visual indication of pump health makes walk around inspections more efficient and accurate. This onboard pump intelligence helps minimize life-cycle costs while maximizing performance.

- Specially Designed Coupling guard: complies with ANSI B15.1 and OSHA 1910.219. The guard offers increased Protection against potential injuries. The guard includes slotted viewing windows for easy inspections. “U” Shape Coupling Guard shall not be acceptable.

- All motors shall be VFD compatible i.e. with better grade of winding insulation to withstand any temperature rise during low RPM operation. Motors shall be TEFC, IP55 rated & Class F Insulation.

- Base shall be of a size suitable for the pump, motor and shaft and shall be constructed or cast iron or welded steel. Flexible coupling shall be protected by a guard mounted on the common base.

- Installation: the pump shall be installed on a concrete foundation with vibration isolators as per approved for construction shop drawings / schedule or quantities. (Civil Foundation not in scope but vibration isolators / VI Pads shall be part of pump supply and installation).

- Pumps Mechanical Efficiency: As called for in the schedule of quantities

As per ECBC: 2017

As per ECBC:	70%
ECBC +	75%
Super ECBC	85%

- Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

- Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

5. HORIZONTAL SPLIT CASING, FLEXIBLE COUPLED PUMP

Horizontal Split Case Pumps flexible coupled with IE2 motor or higher as specified in the BOQ, spacer coupling, OSHA compliant coupling guard, for chilled water cooling systems as indicated on the drawings.

- The pumps shall be long/Flexible coupled, base mounted, single stage, double suction, Horizontal split case design, in cast iron casing & bronze fitted impeller construction specifically designed for quiet operation.

- Pump shall be suitable for a standard operations at 175 PSIG, 12 BAR, PN12 of working pressure upto 300°F temperature.

- Optionally if called for in the schedule of quantities, pump shall be shall be suitable for 300 PSIG, 20 BAR, PN20 working pressure upto 300°F temperature or higher pressure ratings if called for in the schedule of quantities.

- Impeller shall be of the enclosed double suction type made of Low Zinc Silicon Bronze, both hydraulically and dynamically balanced to ISO 1940-1:2003 with balance grade of G 6.3 and keyed to the shaft.

- Pump volute shall be of cast iron ASTM A159 material design with an integrally cast pumps discharge and an integrally cast pump suction. Flanges shall be extra heavy-duty design and will be of 250# thickness while capable of being drilled for 125# ANSI flat face use. Volute shall have integrally cast support feet, gauge ports at nozzles, and vent and drain ports.

- Motors shall meet IE2/IE3/IE4 Efficiency as specified in the BOQ & scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer’s representative . Motors shall be TEFC, IP55 rated & Class F Insulation

- Specially Designed Coupling guard: complies with ANSI B15.1 and OSHA 1910.219. The guard offers increased Protection against potential injuries. The guard includes slotted viewing windows for easy inspections.

- All motors shall be VFD compatible i.e. with higher grade of winding insulation.

- Pumps Mechanical Efficiency: As called for in the schedule of quantities

As per ECBC: 2017

As per ECBC:	70%
ECBC +	75%
Super ECBC	85%

- Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

- Installation: the pump shall be installed on a concrete foundation with vibration isolators as per approved for construction shop drawings / schedule or quantities. (Civil Foundation not in scope but vibration isolators / VI Pads shall be part of pump supply and installation).
- Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

Notes:

- End suction pumps upto flow rate of 2000 GPM per pump or as specified in the BOQ.
- Horizontal split casing pumps above flow rate of more than 2000 GPM per pump or as specified in the BOQ.

6. MONOBLOC PUMPS

a. Pump shall be monobloc end-suction design directly connected to motor with mechanical seal. The pump casing shall be cast iron, Impeller shall be bronze, hydraulically balanced and keyed to shaft. Stuffing boxes shall be integral with casing and water sealed. Shaft sleeve shall be of gun metal extending through stuffing boxes.

b. Pumps shall be suitable for a standard working pressure of 12BAR, 175PSIG, PN12 at 65deg C temperature or of higher working pressure as specified in the schedule of quantities.

c. Motor shall be TEFC, IP55 rated & Class F Insulation, designed as integral part of pump. Motor shall be suitable for 415±10% volts, 3 phase, 50 cycles AC power supply. Motor shall be of IE2/IE3/IE4 efficiency as specified in the schedule of quantities. Motor shall be suitable for VFD application i.e. with higher grade of insulation.

d. Installation: The pump base shall be mounted on a concrete foundation as per on Approved-for-Construction shop drawings.

e. Pumps Mechanical Efficiency: As called for in the schedule of quantities

As per ECBC: 2017

As per ECBC:	70%
ECBC +	75%
Super ECBC	85%

f. Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

g. Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10%V and 50±5% Hz.

h. Installation: the pump shall be installed on a concrete foundation with vibration isolators as per approved for construction shop drawings / schedule or quantities. (Civil Foundation not in scope but vibration isolators / VI Pads shall be part of pump supply and installation).

7. VERTICAL INLINE PUMPS

The Vertical In-Line pump single stage, single or double suction type, with pump characteristics which provide rising heads to shut off, shall be supplied with a TEFC, IP55 rated & Class F Insulation, 415V±10%, 3 phase, 50 Hz, motor efficiency equivalent to IE2/IE3/IE4 as specified in the BOQ and an IP55/UL Type 12 enclosure variable speed VFD if called for in the BOQ for pump mounted drive.

The drive shall be integrated with the motor for a self-contained pump, motor and drive combination to ensure optimum component matching and protection from motor overloading at any operating point within the design or operating range, if called for pump mounted VFD.

Pump Construction:

Casing:

a. Upto 12 BAR, 175PSIG, PN12 working pressure at 65°C temperature:
Pump Casing: Cast Iron with PN16 flanges.

b. Above 12 BAR and upto 25BAR, 375 PSIG,PN25 working pressure at 65°C temperature:
Pump Casing: Ductile Iron with PN25 flanges.

Pumps shall be of working pressure as mentioned in the schedule of quantities.

Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.

Impeller:
Gunmetal Bronze (BS1400 LG2C), fully enclosed type. Dynamically balanced. Two-plane balancing is required where installed impeller diameter is less than 6 times the impeller width.

Shaft:
Provide Stainless Steel pump shaft. Lower carbon throttle bushing, outside balanced type mechanical seal with Resin Bonded Carbon rotating face, sintered silicon carbide stationary seat with Viton secondary seal.

The pump is to be fitted with a factory installed flush line. Supply in the flush line to the mechanical seal. The mechanical contractor shall change the filters after the system has been flushed and on a regular basis until the pumps are handed over.

Coupling:
Rigid spacer type of high tensile aluminium alloy. Coupling to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and replacement without disturbing other components of the pump or motor. The coupling shall be provided with a fully enclosed guard complying with the Machinery Directive.

Motor:
The squirrel cage induction type motor, with TEFC, IP55 rated, & Class F Insulation, enclosure and shall be connected to the pump through a high tensile aluminium, split type spacer coupling to permit Servicing of the mechanical seal without disturbing pump, motor or electrical wiring. Coupling shall be protected by

a guard. Motor shall be suitable for 415V±10%, 3 phase, 50 Hz, motor efficiency equivalent to IE2/IE3/IE4 as specified in the BOQ. Motor shall also be suitable for VFD application i.e. with higher grade of winding insulation.

Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

Pumps Mechanical Efficiency: As called for in the schedule of quantities

As per ECBC: 2017

As per ECBC:	70%
ECBC +	75%
Super ECBC	85%

Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

VFD:

Pump Mounted IP 55 VFD with disconnect switch.
VFD to have THDI not more than 40%
Output cabling from VFD'S to individual pump motors.
VFD shall have display of all the necessary electrical parameters and pump flow & head.
Optional Item* : AHF (Active Harmoic Filter) to lower THDI to not more than 5%
EMC & RFI FILTRATION
VFD's for sensitive installations where life critical data communications are of importance, ike:
• Hospitals
• Airports
• Electronic Industry
• Data centres
• Communication centres
These installations Must have 'C1' category of RFI & EMC filters for 50 meters of cable length. These are applicable to all the VFD's of pumps .

For these above mentioned critical applications, if pump motors are more than 90Kw, then 'C2' category of filters to be used if ' C1' is not available.

VFD's for normal buildings and others similar installations shall have 'C3' category of RFI & EMC filter for pumps.

Refer detailed specifications of VFD's under electrical specifications sub head : PANEL & DISTRIBUTION BOARD,LT SWITCHGEAR,VFD, STARTER , IMPORTANT NOTES 7 CONSTRUCTION FEATURES(SUB HEAD : G of electrical specifications)

8. LUBRICATION

Upon installation of the complete system and before testing, the pump shall be lubricated in strict accordance with the manufacturer's instructions.

9. PUMP ALIGNMENT

Split casing pumps, prior to testing, shall be aligned with a dial indicator within 0.05 mm.

10. WORKING & TEST PRESSURES

Pumps shall be suitable for a working pressures as may be required as called for in the Schedule of

Quantities. Test pressures for the pumps shall be 1.5 times the working pressure of the pump.

11. PAINTING

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

12. PERFORMANCE DATA

Pump performance curves and power consumption with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

13. TESTING

Pump performance shall be computed from the pump curves provided by manufacturer. All pumps shall be tested at factory as per relevant BIS codes. Routine and type test certificates shall be furnished for the pumps.

14. PUMP'S MECHANICAL EFFICIENCY: shall not be less than 70%.

B. VARIABLE SPEED PUMPING SYSTEM

1. SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of variable speed pumping package consisting of following:

a. Individual Components
b. Pump Control Panel
c. Variable Frequency Drive (VFD)
d. Different pressure transmitted (Min. 1 Nos. per zone)
e. Logic Programming for sequence of Operation
f. Power wiring and control wiring shall be carried out by installation contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

2. REFERENCES

a. ANSI - American National Standards Institute
b. NEMA - National Electrical Manufacturers Association
c. UL - Underwriters Laboratories Inc.
d. ETL - Electrical Testing Laboratories
e. CSA - Canadian Standards Association
f. NEC - National Electrical Code
g. ISO - International Standards Organization
h. IEC - International Electrochemical Commission

3. SUBMITTALS

Submittals shall include the following and shall be specific to this project. General Submittals shall not be accepted.

a. System summary sheet.
b. Sequence of operation
c. Shop drawing indicating dimensions, required clearances and location and size of each field connection.
d. Power and control wiring diagrams.
e. System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and Variable Frequency Drive (VFD) efficiencies, job specific load profile, staging points, horse power and kilowatt/hour consumption.
f. Pump data sheets.

4. QUALITY ASSURANCE PLAN

a. The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

b. The manufacturer shall have a minimum of 20 years experience in the design and construction of variable speed pumping systems.

c. The local supplier of Chilled Water Variable Speed Pumping System (VSPS) shall have relevant expertise in all aspects of design, application engineering, installation, programming, interfacing, commissioning and after sales service. Supplier must have commissioned minimum 25 sets of chilled water VSPS in India.

d. All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to VFD output and it shall test all inputs, outputs and program execution specific to this application.

e. The manufacturer shall be fully certified by the International Standards Organization per ISO 9001. Proof of this certification shall be furnished at time of submittal.

f. Manufacturer shall be listed by Underwriters Laboratories as manufacturer of packaged pumping systems.

g. Tenderer shall comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specification shall be clearly defined in writing at time of bid. If no exceptions are taken at time of bid, the supplier shall be bound by these specifications.

5. MANUFACTURED UNITS

a. Furnish and install as shown on the plans a Variable Speed Pumping System as per approved manufacturers.

b. The control system shall include as, a minimum, the programmable logic pump controller, Variable frequency drive(s) and remote sensor / transmitters as indicated in the drawings and schedule of quantities on the plans. Additional items shall be included as specified or as required to properly execute the sequence of operation. The variable speed pump logic controller, Variable frequency drives, VFD bypass if indicated in schedule of quantities, and remote sensor / transmitters shall be shipped as individual components to the job site.

c. Pump logic controller, Variable frequency drives, sensor / transmitters and related equipment shall be installed by the mechanical contractor as shown on the plans.

d. Power wiring shall be installed by the mechanical contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

e. Low voltage wiring shall be installed by the mechanical controls contractor as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

6. PUMP LOGIC CONTROLLER

a. The pump logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory INC. (UL). The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall specifically design for variable speed pumping applications.

b. The controller shall function to a proven program that safeguards against hydraulic conditions including:

i. Pump flow surges
ii. Hunting
iii. End of curve
iv. System over pressure.
v. NPSHR above NPSHA
vi. Motor overload

c. The pump logic controller shall be capable of receiving up to two discrete analog inputs from zone sensor / transmitter as indicated on the plans. It will then select the analogue signal that has deviated the greatest amount from its setpoint. This selected signal shall be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling upto three pumps in parallel.

d. The pump logic controller shall have an additional analog input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.

e. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral and derivative values shall be user Variable over an infinite range.

f. The pump logic controller shall be self prompting. All messages shall be displayed in plain English.

The operator interface shall have the following features :

i. Multi-fault memory and recall last 10 faults and related operational data
ii. Red fault light, Yellow warning light and Green power on light.
iii. Soft-touch membrane keypad switches.

g. The display shall have four lines, with 20 characters on three lines and eight large characters on one line. Actual pump information shall be displayed indicating pump status.

h. Controller shall be capable performing the following pressure booster function :

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

iii. No flow shut down to turn the pumps off automatically when system demand is low enough to be supplied by hydro pneumatic tank. No flow shutdown shall require any external flow meters, flow switches, nor pressure switches to determine when a No Flow condition exists.

i. The following communication features shall be provided to BAS :
  i. Remote system start / stop non-powered digital input.
  ii. Failure of any system component. Output closes to indicate alarm condition.
  iii. One 4-20 mA output with selectable output of :

- Frequency
- Process Variable
- Output Current
- Output power.

j. The following communication features shall be provided to the building automation system via an RS-485 port utilizing Johnson Controls Metasys N2 protocol or equivalent protocol.
i. Individual Analog Input
ii. Individual Zone Set Points.
iii. Individual Pump / VFD on/off status.
iv. System percent speed.
iv. System Start / Stop command
v. System operation mode.
vii. Individual KW signals.
viii. System flow, when optional flow sensor is provided.

k. The pump logic controller shall be a ITT industries technologic 500 or approved equal housed in a NEMA 1 Enclosure.

7. VARIABLE FREQUENCY DRIVE (VFD)

a. The Variable frequency drives shall be Pulse Width Modulation (PWM) type, microprocessor controlled design.
b. The Variable Frequency Drive (VFD), including all factory installed option, be tested to UL standard 508. The VFD shall also meet C-UL and be CE marked and built to ISO 9001 standards.
c. The VFD shall be housed in a NEMA 1 enclosure. AFF with plastic enclosure shall not be acceptable.
d. The VFD shall employ and advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and lift. Power factor shall be near unity regardless of speed or load.
e. The VFD shall have balanced DC link reactors to minimize power line harmonics VFDs without a DC link reactor shall provide a 3% impedance line reactor.
f. Input and output power circuit switching can be done without interlocks or damage to the VFD.
g. The following customer modifiable adjustments shall be provided :
i. Accel time.
ii. Decel time.

iii. Minimum Frequency.
iv. Maximum Frequency.

h. RS-485 communication for Johnson Controls N2 shall be available and provided as an option.

i. An automatic energy optimization selection feature shall be provided. This feature shall reduce voltage when lightly loaded and provide a 3% to 10% additional energy savings.

j. The VFD shall be suitable for upto 3300 feet elevation above sea level without derating. Maximum operating ambient temperature shall not less than 104 degrees F. VFD shall be suitable for operation in environments upto to 955 non-condensing humidity.

k. The VFD shall be capable of displaying the following information in plain English via an alphanumeric display :

i. Frequency.
ii. Voltage
iii. Current
iv. Kilowatts per hour
v. Fault Identification.
vi. Percent Torque.
vii. Percent Power
viii. RPM

NOTE: VFD FOR PUMPS:

a. VFD's for pumps shall have DC Chokes to achieve THDI less than 40%.
b. DC chokes shall be part of / inclusive in VFD enclosure.
c. EMC & RFI FILTRATION

VFD's for sensitive installations where life critical data communications are of importance ,like:
• Hospitals
• Airports
• Electronic Industry
• Data centres
• Communication centres

These installations Must have 'C1' category of RFI & EMC filters for 50 meters of cable length. These are applicable to all the VFD's of pumps .

For these above mentioned critical applications, if pump motors are more than 90Kw, then 'C2' category of filters to be used if ' C1' is not available.

VFD's for normal buildings and others similar installations shall have 'C3' category of RFI & EMC filter for pumps.

8. AUTOMATIC VFD BYPASS

a. Variable speed pumping system shall be equipped with an automatic bypass in accordance with requirement of Schedule of Quantities.

b. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contractors and a motor overload relay. All are to be mounted in a NEMA 1 enclosure.

c. Automatic bypass shall operate as shown in schematic drawings described in the sequence of operation.

9. SENSOR / TRANSMITTERS

a. Provide field mounted differential pressure sensor transmitters as indicated in BOQ or on the plans. Unit shall transmit an isolated 4-20mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have a corrosion resistant steel body with 1/8" NPT process connection. It shall have a NEMA 1 electrical enclosure capable of withstanding 450 PSI static pressure. Accuracy shall be within 0.5% of full span. The installation contractor shall ensure that these differential pressure sensor are enclosed within pilfer proof housing such MS plate housing with lockable

access panel.

10. PRIMARY/SECONDARY VARIABLE SPEED PUMPS

Pumps specifications are covered in the PUMPs specifications sub head. To be refered from there.

11. SEQUENCE OF OPERATION

a. The system shall consist of a pump logic controller, multiple pump / VFD sets, with manual and automatic alternation and pump staging.

b. The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.

c. When the pump logic controller selector switch is in the LOCAL position, and start command on Tech 500 is given via operator interface, the pumping system shall operate automatically.

d. Sensor / transmitters shall be provided as indicated on the plans.

e. Each sensor / transmitter shall send a 4-20 mA signal to the pump logic controller, indicative of process variable condition.

f. The pump logic controller shall compare each signal to the independent, engineer / user determined set points.

g. When all set points are satisfied by the process variable, the pump speed shall remain Constant at the optimum energy consumption level.

h. The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.

i. If the set point cannot be satisfied by the designated lead pump, the pump logic controller shall initiate a timed sequence of operation to stage a lag pump.

j. The lag pump shall accelerate resulting in the lead pump(s) decelerating until they equalize in speed.

k. Further change in process variable shall cause the pumps to change speed together.

l. When the set point criteria can be safely satisfied with fewer pumps, the Technologic pump logic controller shall initiate a timed destage sequence and continue variable speed operation.

m. As the worst case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the VFD to speed up or slow down the pump / motor.

n. In the event of a VFD fault, the pump logic controller automatically initiates a times sequence of events to start the redundant pump / VFD set in the variable speed mode. The redundant variable speed system shall be started through the pump logic controller.

o. Upon VFD fault(s), the pump controller shall display an alarm condition through a plain english message.

p. VFD fault indication shall be continuously displayed on the operator interface of the pump until the fault has been corrected and the controller has been manually reset.

q. In the event of the failure of a zone sensor / transmitter, its process variable signal shall be removed from the scan / compare program. Alternative zone sensor / transmitters, if available, shall remain in the scan / compare program for control.

r. Upon sensor failure a plain english warning message shall be displayed on the operator interface of the pump logic controller.

s. In the event of failure to receive all zone process variable signals, a user selectable number of VFDs shall maintain a user Variable speed, reset shall be automatic upon correction of the zone failure.

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SUBHEAD-B. PLATE HEAT EXCHANGER SPECIFICATION

SECTION 1 - GENERAL

1.1 Scope

1.1.1 This specification covers the requirements for design, materials, fabrication and testing of Plate Heat Exchangers.

1.2 Definitions

1.2.1 Plate Heat Exchanger - Is a pressure vessel consisting of a set of gasketed heat transfer plates supported in a frame capable of easy opening and closing.

1.2.2 Plate Pack - Is the assembly of plates, which form the hot and cold fluid channels.

1.2.3 Gaskets - Contain the process fluids between the plates and direct the fluids into their respective flow channels.

1.2.4 Fixed Plate - Is the stationary end of the exchanger. Customer connection ports should be located on this cover.

1.2.5 Pressure Plate - Is the movable end of the exchanger. This head can be moved away from the plate pack, thus permitting access to the plates for inspection or cleaning.

1.2.6 Ports - Customer connections, which should be studded.

1.2.7 Carrier Bar - Is the top bar from which plates are hung. The carrier bar is supported by the fixed plate, and the pressure plate or end support. Plate sliding surface should be lined with SS-316 strip.

1.2.8 Guide Bar - Is the bottom guide for the plates and movable head. It is attached to the fixed plate, and the pressure plate or end support.

1.2.9 Tie Bolts & Nuts - Hold the plate assembly together between the fixed and movable heads.

1.2.10 End Support - Supports the carrier bar and guide bar for larger units.

1.2.11 Frame - Is the assembly that provides the structural support and pressure containment for the plates. It consists of the fixed plate, pressure plate, carrier bar, guide bar, tie bolts, nuts and end support.

SECTION 2 - GENERAL REQUIREMENTS

2.1 Limits of Supply

2.1.1 Seller shall provide a fully assembled exchanger, requiring no additional on-site assembly.

2.1.2 Items to be supplied by others.

a) Anchor bolts

b) External process piping, nuts etc

2.2 Performance Guarantee

2.2.1 Vendor shall warrant goods against faulty workmanship or the use of defective materials, under normal use and service, and that such goods will conform to mutually agreed upon written specifications, drawings and are guaranteed to meet specified performance requirements, for a period of twelve (12) months from the date of shipment.

SECTION 3 - DESIGN REQUIREMENTS

3.1 Thermal Design

3.1.1 To maintain velocity and reduce fouling, unit shall be sized to provide 20% of the extra area then required.

3.1.2 The unit shall be designed for future expansion to accommodate a minimum of twenty (20) percent extra heat transfer surface area.

3.1.3 Liquid velocity through the inlet and outlet ports shall be a maximum of 5 m/s, to optimise pressure drop and erosion.

3.2 Mechanical Design

3.2.1 Frame, tie bolts, and supports shall permit the future installation of twenty (20) percent additional plates. This will also allow ease in disassembly and cleaning of the unit as furnished.

3.2.2 Plates

a) Minimum thickness of each plate shall be 0.5 mm.

b) The plate nozzle connections shall be arranged to force each fluid across the plate surface in a parallel path (i.e. inlet & outlet connections shall be on same side and not diagonal).

c) Plate design must be adequate to withstand a hydro test pressure of 1.3 times the design pressure. Each side shall be pressurized independently during testing.
d) Gasket grooves must be designed such that it holds the gasket from three sides.
e) Plates must be supported by the carrier bar. Carrier bar surfaces that are in contact with the heat transfer plates shall be stainless steel. The plate should have provisions for self-aligning outside heat transfer area.
f) The guide bar shall be designed to maintain plate alignment. Guide bar shall not be used for support. Guide bar shall be stainless steel.
g) The first and last plates of the plate pack shall be designed to prevent fluid contact with the fixed or movable heads.

3.2.3 Gaskets

a) Gaskets shall be of the non-glued design.
b) All gaskets must be elastomeric. Inelastic gaskets, such as compressed asbestos, must not be used.
c) Gaskets shall be designed so that the gasket groove on plate is in their metallic contact from three sides.
d) Port holes in each plate must be fully gasketed and vented to the atmosphere to force any leaks to the outside. This form of positive venting will eliminate mixing of the process fluids due to gasket failure.

3.2.4 Fixed and Pressure Plates

a) All nozzle connections shall be located on the fixed plate for single pass arrangement.
b) For tie bolts of 1 inch or greater diameter, the fixed and pressure plates shall be provided with slotted holes, to facilitate assembly and disassembly of the unit.
c) The pressure plate shall be supported by the carrier bar and guided by the guide bar.
d) Unit design shall prevent the fixed and pressure plate from contacting the fluids circulated. Metal nozzle liners compatible with the plate material, or nozzle projections shall be provided.

3.2.5 Tie Bolts and Nuts

a) The tie bolt length shall allow the addition of twenty (20) percent more plates.
b) Tie bolts and nuts shall be EN18, zinc plated for improved corrosion resistance.

3.2.6 Ports

a) For units with studded ports, corrosion resistant stud bolts shall be provided by the manufacturer.
b) Metal port liners shall be provided per 3.2.4 above.

SUBHEAD-C. DOUBLE SKIN AIR HANDLING UNITS, TREATED FRESH AIR UNITS & HEAT RECOVERY WHEELS/UNITS - DIDW CENTRIFUGAL FAN BASED AHU'S

1. SCOPE

The scope of this section comprises the supply, erection, testing and commissioning of double skin, sectionalized construction air handling units, conforming to these Specifications and in accordance with requirements of drawings and of the Schedule of Quantities. The units shall be floor mounted horizontal/vertical type & ceiling suspended type as indicated in the Schedule of Quantities.

2. TYPE

The air handling units shall be double skin construction, draw-thru type comprising of various sections such as mixing box, (wherever the return air is ducted), filter section, coil section, HRW section and fan section, as mentioned in schedule of quantities. Each unit shall be factory built modular type with field assembled casing sections.

3. CAPACITY

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

4. CASING & DRAIN PAN

Double skinned sandwiched panels shall be 46 mm + 2 **mm for Non Thermal Break AHU's & for Indoor AHU's , 46 mm ± 2mm** thick for Thermal Break AHU's & for TFA's / TFA cum HRW's, made of galvanized steel, pressure injected with HFC/CFC free polyurethane foam insulation (density 40 kg/m^3) with K factor not exceeding 0.02 Watt/m K 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 pre-coated plasticized Galvanised steel sheet 1.0 mm thick, and inner sheet 0.8 mm thick plain Galvanised steel Sheet.

Alternatively quote with rockwool insulation material of density 60 kg/cum between both inner and outer skin, in place of PUFF , if mentioned specifically in the schedule of quantities.

Note: For AHU's for Hospital application for OT's, the inner sheet shall be plain Aluminium in place of Galvanised Sheet. The thickness of Aluminium sheet shall be 1.0 mm thick.

Note: Ceiling suspended AHU's shall be with sandwitch panel of Thermo – Accoustic design with 23mm pressure injected HFC/CFC free polyurethene foam (density 40 kg/m3) to act as thermal insulation and 25mm thick open cell Nitril rubber of 120-140 Kg/m3 density to act as acoustic insulation. Panel thickness shall 46±2mm.

The entire framework shall be mounted on an aluminium alloy or heavy gauge rolled / formed having pressure die cast aluminum jointers with lifting arrangement 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.

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 gauge stainless steel SS 304 sheet with all corners welded. The tray shall be insulated with 13 mm thick class 'O' closed cell Nitril rubber with GI sheet at bottom. Tray shall have multiple slopes for fast removal of condensate drain.

5. THERMAL BREAK PROFILE

Thermal break profile to be provided for:

- TFA Unit, indoor as well as outdoor type.
- TFA cum HRW with cooling coil.

- AHU with mixing box with ducted return even if its indoor.
- Outdoor AHU.

Thermal break profile as indicated in schedule of quantities. All these unit's shall be provided with 46±2 mm thick panel. The thermal break design shall be applied to both panel & profile.

All outdoor AHU's / TFA's / HRW units/TFA cum HRW units shall have canopy on top.

6. MIXING BOX SECTION

AHU's requiring mixing boxes as specified in Schedule of Quantities shall be complete with fresh and return air dampers.Dampers shall be manual/motorized with actuator as may be required.

7. DAMPER

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 motorized operation. Damper frames shall be sectionalized to minimize 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. Dampers may be motorized with actuator if called for in the schedule of quantities.

8. MOTOR AND DRIVE

Fan motors shall be energy efficient IE2/IE3/IE4 as specified in the schedule of quantities and shall be 415±10% volts, 50 + 5% 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. Drive to fan shall be provided through V- belt-drive arrangement. Belts shall be of the oil-resistant type. Belt drive shall have protection ground. Motor shall be suitable for VFD operation i.e. improved winding insulation to withstand any temperature rise due to operation at lower frequencies.

Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

9. FAN SECTION & FAN SELECTION

Fans shall be centrifugal, DIDW (Double Inlet Double Width) backward / forward curved blades as specified in the schedule of quantities. Forward curved fans may be used in some ceiling suspended AHU's if specified in the schedule of quantities. Fans driven by variable frequency drive shall be backward inclined. Fans shall be selected for maximum efficiency. Fan casing shall be made of galvanized steel sheet. Fan wheels shall be made of galvanized 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 have to be submitted along by the contractor.

Motors shall be mounted inside the AHU casing on slide rails for easy belt tensioning, and be TEFC, IP55, class `F' insulation. Motors shall drive heavy duty V-belt, constant pitch, drive selected at 110% of motor horsepower. Motor speed shall not be more than 1440 RPM.

Both fan and motors assemblies shall be mounted on a deep section aluminium alloy or galvanized steel (depending on size) base frame.

Spring Isolators shall be provided for isolating the fan & motor assembly from the AHU casing. Fire

retardant, waterproof, silicone rubber impregnated flexible connection shall be provided at the fan discharge.

Fan shall be AMCA certified for performance & sound.

Noise level shall not exceed 68-70db @ distance of 1m from the AHU in all the directions.

Fan's mechanical efficiency : not less than 70% for Backward curved fans. And 65% to 70% for Forward curved fans.

Fan outlet velocity shall not exceed 9.2 m/s (1800 FPM)

FAN SELECTION

- All floor mounted AHU's TFA's, TFA's CUM HRW Units shall have high efficiency backward curved DIDW Centrifugal fans irrespective of static pressure requirement. These fans shall be AMCA certified & sealed for performance & sound power.

- Ceiling Suspended AHU'S upto 50 mm total static pressure shall have Forward Curved DIDW Centrifugal fans & above 50 mm total static pressure shall have high efficiency backward curved fans. These fans shall be AMCA certified & sealed for performance & sound power.

- VFD driven fans, be it ceiling suspended AHU or floor mounted AHU / TFA shall essentially be with Backward Curved fans.

10. COOLING & HEATING COILS SECTION – WATER COILS, CHILLED WATER & HOT WATER

Chilled water & hot water coils shall have 12.7 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 2.54 meters/second (500 FPM). The coil shall be pitched in the unit casing for proper drainage. The coil shall have copper header with supply & return connections protruding out of AHU casing by minimum 150 mm and fitted with dielectric coupling for connection with MS pipes. Copper header shall be of minimum 1.6 mm thickness. Fin spacing shall be 4 - 5 fins per cm. (11-12 Fins per inch.) Fins thickness shall not be less than 0.15 mm. Water pressure drop in coil shall not exceed 10 PSIG.

Each coil shall be factory-tested at 21kg per sq.m air pressure under water. Tube shall be hydraulically / mechanically expanded for minimum thermal contact resistance with fins.

The cooling coil segment shall have a full width, multi sloped drain pan that extends downstream of the coil to provide sufficient amount of space to contain moisture carry-over. The unit design shall not require a drain pan in any downstream section to contain the coil condensate. Drain pan must be accessible for inspection and cleaning.

Stacked coils shall have an Intermediate drain pan extending to the entire finned length of the coil. Cooling coils in stacks - section shall not be acceptable unless provided with an intermediate drain pan. The intermediate drain pan shall have drop tubes to guide condensate to the main drain pan. Maximum coil length shall be 3.5 meters.

WATER SIDE COIL WORKING PRESSURE: as specified in the schedule of quantities

Coil Working pressure* = 150 PSI/10kg/cm²/PN10*
OR
Coil Working pressure* = 235 PSI/16kg/cm²/PN16* (for tall buildings)

OR
Coil Working pressure* = 300 PSI/20kg/cm²/PN20* (for tall buildings)

The Coil test pressures shall be 1.5 times of working pressures.

WATER COIL ROW DEEPNESS

- Floor mounted AHU'S shall have 4 Row / 6 Row / 8 Row deep cooling coils as called for in the BOQ.
- Ceiling suspended AHU'S shall have 4 Row / 6 Row / 8 Row deep cooling coils as called for in the BOQ.
- Preheat / Reheat coils shall be 2 Row deep.
- TFA & TFA CUM HRW with cooling coils shall have 8 Row deep coils (Floor mounted as well as Ceiling Suspended areas.
- TFA'S & TFA CUM HRW or AHU'S with 100 % Fresh Air shall have coils with fins with hydrophilic coating to prevent water / moisture carry over.

Water Coils shall be AHRI certified for performance / capacity & for water and air side pressure drops. (Latest AHRI – 410 latest standard)

Computerized cooling coil selection output shall be submitted by the Contractor to cross – check the coil row deepness.

DX COILING COIL

- For all AHU'S with DX- Coil, coil row deepness shall be 4 Row or 6 Row as mentioned in the BOQ.
- The coil shall have 9.52 mm dia (OD) & made from seamless solid drawn copper tubes. The minimum thickness of tube shall be 0.5 mm for cooling coils.
- The depth of the coil shall be such as to suit the requirements which is re-circulated air applications or 100 % fresh air applications. The coil row shall be selected as per the coil selection computerized software and cooling coil data output shall be submitted. Minimum row deepness shall be 4 row deep.
- Each section of the coil shall be fitted with flow and return headers to feed all the passes of the coil properly. The headers shall be of copper.
- The fins shall be of aluminum. The minimum thickness of the fins shall be 0.15 mm. Fin spacing shall be 12 fins per inch (4-5 fins per cm). Fins may be sine wave/corrugated type. The tubes shall be mechanically expanded for maximum thermal contact between fins and tubes. The fins shall be evenly spaced and upright. The fins bent during installation shall be carefully realigned.
- For 100 % fresh air application, Fins shall be hydrophobic or hydrophilic coated type to prevent water / moisture carry over.
- DX Coil re-circulatory AHU's with cooling coil shall have 4 row deepness or on actuals based on computerized coil selection
- DX Coil AHU's with 100 % fresh air or TFA's & TFA's cum AHU with cooling coil shall have 6 Row / 8 Row deepness as mentioned in the BOQ.

- Each coil shall be factory tested at 600 PSI. Pressure & Face velocity across coil shall not exceed 500 FPM.

- Stacked coils shall have an Intermediate drain pan extending to the entire finned length of the coil. Cooling coils in stacks - section shall not be acceptable unless provided with an intermediate drain pan. The intermediate drain pan shall have drop tubes to guide condensate to the main drain pan. Maximum coil length shall be 3.5 meters.

- **IMPORTANT NOTE:-**
  A. Coil Row deepness as mentioned in BOQ is to be cross-verified by the Vendor / Contractor by calculating heat load calculation, checking ESHF, ADP, Sensible & latest load & running the coil selection software and to be shared with the Consultant / PMC / Client.

  B. The software selection need to be checked / approved by the Client / Consultant / PMC.

  C. If as per the accepted and approved software calculation, the coil row deepness required comes more than the specified in the BOQ, then the higher row deepness to be considered, for which no extra claims will be applicable.

  D. And if as per the accepted and approved software calculation, the coil row deepness required comes lower than the specified in the BOQ , then the row deepness as specified in the BOQ to be adhered to.

11. FILTERS SECTION

11.1 Pre-Filter Section:

Pre-Filter section shall be non-woven synthetic supported by HDPE mesh on one side with 50 mm thickness shall be provided on the suction side of the AHU with efficiency of 90% down to 10 micron particle size. Filter shall have anodized aluminium frame. Pre-filters shall be type MERV-8. Filter face velocity shall not to exceed 500 FPM. These filters are cleanable by Air.

11.2 Fine Filter Section (Optional, If asked for in the BOQ):
Fine Filter section shall be non-woven synthetic supported by HDPE mesh on one side (if called for in the Schedule of Quantities) shall be with an efficiency of 99% down to 3 micron particle size and shall be with anodized aluminium frame. Filter banks shall be easily accessible and shall be designed for easy removal & renewal of filter cells. Face velocity across fine-filters shall not exceed 500 FPM. The filter loading mechanism shall be front loading. Fine filter shall be type MERV – 14 .Bag filter shall be 300 mm thick whereas mini pleat type shall be 100 mm thick and shall have paper media. Bag filters are cleanable by Air. Whereas mini pleat filters shall be use and throw type. Type of filters to be provided as per BOQ.

11.3 HEPA Filter section (Optional, if called for in the schedule of quantities):
HEPA Filter section (if called for in the schedule of quantities) shall be with an efficiency of 99.97% down to 0.3 micron particle size. These shall be confirming to EU-13 standards. HEPA Filter shall be provided at the discharge side of AHU. Filter face velocity shall not be more than 500 FPM. These filter shall be use and throw type

11.4 Electronic Air Filtration System / Electronic Air Cleaner (ESP's) (Optional, If asked for in the BOQ):

The electrostatic precipitator Electrostatic Air Cleaner (EAC) an electric charge to remove impurities – either solid particles or liquid droplets – from the air. The electronic air cleaner shall function by applying energy only to the particulate matter to be collected without significantly impeding the flow of air.

Two stage electronic air cleaner shall consist of two sections a charging section and a collection section. A high voltage shall be applied to the ionizing wires to form a strong electric field between the wires. Electrons present in contaminated air containing pollutants such as fine duct, smoke particles, pollens, mould spores and bacteria shall be pushed at high velocity (due to strong Coulomb Forces) from the negative charged electric field to the positive charged electric field. Along the way they collide with the contaminants, releasing more electrons.

The ionized particles shall be moved by the moving air into the strong electric field at the collectors and are trapped at the charged collector plates.

Electronic cells and pre-filters shall be washable and reusable type. EAC'S shall meet MERV-14 rating (99% down to 3 micron particle size). Pre filter shall be used before Electronic Air Cleaner as its integral unit in a common assembly.

Technical features

ESC shall have following indication:

- Power 'ON'
- Check light 'ON' (Will even 'ON' if there is any problem in the filter or moisture / water droplets are left after washing.
- Wash light 'ON' (will turn 'ON' if filter becomes dirty)

ESP'S shall be 'UL' listed & 'UL' mark

• Capacity. 1000 cfm (1700 m^3/hr) on F58H 2000 cfm (3400 m^3/hr) on F58G	• Solid state power supply • Able to maintain peak efficiency during a wide range of cell dirt-loading conditions
• Interconnectable units to form array of air cleaners	• Test button checks system operation
• Connectable to Building Management Systems	• Heavy duty commercial cells and pre-filters are removable for cleaning.

Technical Data of Electronic cells

Capacity	1000 cfm (1700 m^3/hr)	2000 cfm (3400 m^3/hr)
Mounting	Duct Mounted / AHU Mounted	
Housing	Galvanised Steel Cabinet	
Operating Ambient	4 ºC to 52 ºC	
Dimensions	350 x 610 x 171 mm	670 x 610 x 171 mm
Certifications	UL/PSB/MERV-14	
Electrical Rating	Voltage and Frequency Power Supply: 220 – 240 Vac, 50 HZ Power Consumption : 36 W Maximum for 2000 cfm unit Current Draw : 0.2 A Ionizer Voltage : 8150 Vdc Collector Voltage : 4075 Vdc	

TFA / AHU's shall be fitted with a true electronic air cleaner system if called for in the BOQ, (complete with washable pre-filter, charging section and collector section) to be installed before the cooling coils.

Electronic Air Cleaner shall be a hybrid air purification system that improves the indoor air quality by reducing harmful pollutants like particulate matter (PMx), PM 2.5, allergens, pollen, smoke, bacteria, pathogens based on Electrostatic precipitation technology. Other forms of air filtration systems such as charged media filters, dielectric media filters, or ionizers (which do not have second stage collector plates) shall not be acceptable. It should be a monobloc structured unit. It should be equivalent to **MERV14 efficiency @ 1708 cfm** with low pressure drop of not more than 65Pa @ 492fpm (certification for the same to be provided). It should be UL listed with in built provision to connect to BMS. The product has to be certified as a green product by any of the Green Building councils across the world. The central air cleaner units must have a valid ANSI/ASHRAE 52.2 test report to verify filtration efficiency. The unit must have factory test report to ensure that it meets the following safety and environmental criteria with reference to ES164468, UL 867 and DA 6.2.1. Ozone level of units provided must be within the acceptable limit of 0.05ppm. The units shall have local LEDs at each individual unit to indicate when the units are up for wash / malfunctioning.

Optional (with Activated Chemical Filter), if called for in the BOQ:
The EAC shall have activated carbon (Charcoal) filter for the removal of 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. The frame of the carbon filter to be made of Aluminium. Material for Carbon filters should be 3/8"Carbon Impregnated foam, 30 PPI. The EAC should be as required by the specifications.

b. Approvals / Code Requirements

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.

Ozone level of EACs provided must be within the acceptable limit of 0.05ppm. Tenderers must also provide a test report to confirm conformance.

c. Factory Safety Test Report

The EAC must have factory test report to ensure that it meets the following safety and environmental criteria with reference to ES164468, UL 867 and DA 6.2.1:

Performance Testing

- Dielectric test
- Ambient and voltage extremes
- E-field test
- Oscillatory transient test
- Lightning test
- EFT (fast transients) test
- ESD (high voltage transients) test
- EMI susceptibility test
- EMI radiation test

Environmental

- Humidity
- Condensation
- Vibration

All tenderers must submit a design analysis conditional qualification test report to confirm that tests have been conducted based on the above criteria and that the EAC has passed these tests.

d. Safety Provisions

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 tension power supply unit to indicate the presence of high voltage on the electronic cells. An overall test button for a group of power supply units to provide a general indication of high tension voltage is not approved.

e. Performance / Reliability Requirements

The average capacity of the EAC shall be at least 1000cfm for the single cell unit and 2000cfm for the double cells unit.

The initial atmospheric dust spot efficiency (ASHRAE 52-76) of the EAC shall be at least 67% at 2000cfm and up to 95% at 800cfm. 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 collecter section. The voltage to the ionizer shall be atleast 8000V 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 shall be atleast 4000V DC.

For the EAC to perform effectively against PM 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 to 0.4 µm	68%
1.6 to 2.2 µm	92%
2.2 to 3.0 µm	94%

The entire Filteration 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 65 pa at 2000cfm and 2.5 m/s airflow. The tungsten ionizing wires and aluminum collector plates shall be integrated within one pack. It shall be washable for repeated use. A washable aluminium mesh prefilter 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 prefilter. A washable aluminium mesh prefilter 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) filter for the removal of 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.

f. Diagnostics / Interfacing to Building Management System

The EAC shall have the capability of interface with the building management system through a Solid State Performance Indicator (SSPI). The following status shall be allowed for remote monitoring by the building management system as common fault:

1. Normal operation of solid state power supply (ON)
2. Any malfunction of the system that shall cause an alarm activation (CHECK)

3. Excessive dirt accumulation in the collector cells that could result in the reduction of the EAC performance (WASH)

The EAC shall have local LEDs at each individual unit to indicate the above status and it shall be able to provide in addition a signal to link-up with the building management system for monitoring.

g. Submission of Compliance Documentation

Tenderers must submit a Clause-by-Clause Compliance Summary and provide full documentation /technical literature /data sheets /reports to confirm compliance for each clause. Please also submit a project reference list.

11.5 Filter's Technical Data

MEDIA FILTERS

- MERV 8 : 90% efficient down to 10 microns
- MERV 14 : 99% efficient down to 3 microns
- MERV 14 : 99% efficient down to 3 microns
  or
  95% efficient down to 1 micron
- HEPA : 99.97% efficient down to 0.3 microns

ELECTRONIC AIR CLEANER

- ESC : 95% efficient down to 1 micron
  or
  : 98% efficient down to 2 microns
  or
  : 99% efficient down to 3 microns

12. CHEMICAL/GAS PHASE FILTERATION – (optional, if called for in the BOQ)

The chemical filter should be designed to remove atmospheric pollution, corrosive gases such as SOX, NOX, H2S, SO2, NO2, VOC's, OZONE, Hydrocarbons and other vapours and gaseous odours prevalent at site. The inlet air quality to be considered as GX/G3 level and the leaving air should be of G1 class. The Chemical Filter shall be skid mounted and suitable for vertical installation / or suitable for installation within AHU's as a separate filter section.

The chemical bed thickness shall be selected for suitable air quantity (as per site conditions) and based on chemical composition of the air at the inlet of the chemical bed, outlet as per site condition. The Chemical Filter shall remove the corrosive gases by reacting with them chemically and converting into non toxic, harmless solids. The reaction products thus formed shall be trapped into the voids of Chemical Media Pallets thereby eliminating the possibility of desorption. The Chemical Media to be used shall be UL Class 1 non-flammable, Nontoxic.

Removal of Gases by Chemisorption

- Adsorption: In this process corrosive gases are attracted and held on the surface of Chemical Pellets. Absorption is a Surface phenomenon.
- Absorption: The gases thus absorbed are absorbed into the inner structure of the Chemical Media Pellets.
- Chemisorption Process (Oxidation): The chemisorption's process shall remove contaminant gases by means of absorption, absorption and chemical reaction. Gases shall be trapped within the pellet where oxidation changes the gases into nontoxic, harmless solids, eliminating the possibility of desorption. This process is essentially instantaneous & irreversible.
- The pressure drop across filter @500 FPM shall not be more than 15mm WG for a 100mm thick AHU mounted filter.

13. HUMIDIFIER SECTION: optional item, if asked for in the BOQ

a. Ultra-Sonic Humidification with EC Fan - Motor

Humidifier shall have the following specifications:

Cabinet Construction

- The frame and panels shall be constructed of heavy gauge corrosion resistant sheet steel and have modular construction with railing and hinged doors.
- The cabinet shall be powder coated and have a textured finish.
- The cabinet Shall be provided with double skin side panels with inner panel of minimum thickness of 0.8mm and outer panel of thickness of 1.0mm
- Insulation in the side panels should be 19 mm thick glass wool and front & back panels should be insulated with 25 mm thick special acoustic mineral wool.

Discharge Direction

- Airflow through the unit to the top (up-flow direction)
- Fan Blowing out of the unit
- Air Suction from the front of the unit.

Humidification Unit (14 Kg/hr, 28 Kg/hr, 42 kg/hr and in multiplex of 14 kg/hr)

Consisting of the following components:

- 1 Reverse Osmosis unit
- Ultrasonic humidifiers each of 14 Kg/hr capacity (14 litre/hr)
- 14 Kg/hr humidifiers connected in parallel to get more output.
- The unit will have it on Humidity sensor probe.
- Temperature and RH display shall also be available.

The Ultrasonic humidifiers are controlled proportionally and separately by means of an analogous signal 0-10VDC from the controller. The humidifier alarms caused by overcurrent are also treated individually. The drain valves are controlled in parallel.

Reverse Osmosis Unit
five-stage water filtration and cleaning by
1st stage: 5 µm sediment filter
2nd stage: activated-carbon granulate filter
3rd stage: carbon filter block
4th stage: TFC membrane (reverse osmosis process)
5th stage: carbon afterfilter

After a pre-filtration in stage 1 to 3 the drinking water is pressed through a semipermeable membrane in stage 4. At the high pressure side a high ion concentration is prevailing, which must be regularly flushed into the waste water system. At the low pressure side pure water is obtained. An incorporated TDS-measuring device measures the total dissolved solids.
Errors, runtimes and a necessary filter or membrane exchange are indicated by the integrated microcomputer. The unit is equipped with an automatic flushing and cleaning function.

Technical data:

Permeate capacity:	12,5 l/h 302 l/d
Retention:	> 95%
Waste water - pure water ratio:	2:1 to 3:1
Water tank volume:	12 l

Application conditions:

max. raw water conductivity:	2000µS/cm
max. raw water hardness:	30°dH
max. blocking index:	SDI 5
Raw water pressure:	0,35 - 5,5 bar
Raw water temperature:	5 - 45°C

no presence of strontium nor barium in the raw water
bacteria concentration according to Drinking Water Ordinance

Ultrasonic Humidifier of 14 Kg/hr (14 litre/hr) unit
Universal humidification system based on ultrasonic atomization of water, installed in the medium section of the humidification unit, consisting of:

- Mist producer with oscillators in modular combination in a plastic housing
- Electronic part
- Water inlet valve, dry-running protection and water level control
- Drain valve controlled by controller
- Console made of stainless steel and non-corrosive screws
- GI Powder coated condensate tray for additional safety
- Transformer for installation in the electric cabinet, secondary 48 V

Function: entirely automatic production and delivery of odourless, demineralized mist by means of ultrasonic waves. The humidification is free of germs, a bacteriologic contamination is prevented by ultrasonic waves. The mist output is realized by specially designed discharge domes. The domes are executed as a labyrinth at the inside to retain big drops.

Technical data per of Humidifier (14 Kg/hr or 14 litre / hr)
Humidification capacity: 14 litre / hr
Control mode: proportional (pulse operation)
Number of mist producer units.: 24
Power consumption: 750 VA
Electrical connection: 48 V 1 Ph / 50 Hz
Dimensions L x D x H: 785 x 200 x 175 mm

Operating conditions:
Supply water conductivity: < 20µS/cm
Supply water pressure: 0.5 - 6 bar
Supply water temperature: 5 - 40°C

High performance EC-radial fan:

- Direct driven fan
- Single suction
- Twofold backward curved blades
- Statically and dynamically balanced in two planes (G 6,3 DIN ISO 1940)
- Electronically commutated motor with integrated electronic for connection to a microprocessor system
- Inherently safe motor with alarm output
- Fan speed can be electronically controlled
- Standard softstart
- Control from the microprocessor
- Bus connection (RS485)
- Multi-range voltage at 50/60 Hz
- Integrated current limitation
- Anti-corrosive aluminium impeller
- Low vibration
- Low noise operation
- Wear-resistant
- Maintenance-free

Electric cabinet:

- Design of the cabinet according to VDE and DIN standards
- Filter monitor
- Accommodation of high voltage and control components
- Accessible from the front
- Installed main switch with operability from outside
- Clear and space saving structure of high voltage and control components
- Completed wiring of motor circuit breakers, contactors and control components in wiring ducts
- Top hat rail system for high voltage components
- Main power supply provided by customer

Feeding direction:

- Power supply and piping connection from bottom

Voltage:
380 V - 415 V, 3ph, 50 Hz with N and PE protective conductor
Control System:
System consisting of I/O-controller **(Microprocessor based controller and suitable for software integration with BMS**) and, depending on functionality, further expansion boards.

IO-Controller:

- Supply voltage: 24 V (+15%/-15%) VAC
- I/O-board interface: RS485
- Service, download- and printer interface: RS232
- 4 sensor inputs: signal current 0-20 mA or 4-20 mA or signal voltage 0-10 V
- 1 analog universal input, and passive sensor (0-10V, 0/4-20mA, 4-conductor: PT100, PT1000, PTC)
- 11 alarm inputs: 24 VAC/DC (+ 24V = no alarm) status display via LED's

- 4 analog outputs: 0-10 VDC; max. load 20 mA
- 7 digital outputs (relais with two way contact), 24 VAC, max. 6 A, status display via LED's

Controller to be installed in electrical cabinet of a unit with following properties:

IO-Controller

- Automatic or manual start after power loss, unit start time delay also selectable for individual components.
- Free allocation of all digital/analoge inputs and outputs at respective terminals.
- Service warning according to pre-set time intervals.
- Manual operation of fan, humidifier and drain valve possible.
- recording of up to 200 alarms with time and date
- Temperature and humidity recording up to 1440 data points, freely scalable within 1 to 60000 minutes
- Variable alarm delay, selectable alarm priority, text input for auxiliary alarms.
- 1*common alarm
- RS232 port on microprocessor board for servicing and software upload. Print out of alarm protocols, temperature/humidity values, diagnostics and parameter setting
- Serial RS485 interface available for connection to user interface Advanced Terminal
- Sequencing of all connected IO controllers
- Sequencing can be divided in up to 20 zones
- Turn over conditions: unit failure and selectable temperature for Std-By unit activation
- selectable sequencing time
- alarm priority configuration
- Modbus protocol preinstalled (BMS interlinking – Software integration)

The following functions can be controlled and supervised:

- Humidification
- Control and supervision of limit values for return air humidity with supply air limitation. Mean average value control when more than one sensor of the same type is used.
- Supervision of following signals: airflow, humidifier overcharge, conductivity measurement optionally: water detector, phase supervision, UPS, 4 auxiliary alarms.

Accessibility: Service Area

- The unit shall be accessed from front which will be enabling to access all the main components of the machine from the front for installation purposes and routine servicing.
- The unit shall be serviceable from the front with a maximum service space required of 1 mtr.

b. Steam Electrode Humidification pan type Humidifier

Electric Resistance Type Pan Humidifier shall consist of:

- Based on Isothermal humidification.
- High resistance heaters dipped in water, used to heat the water and produce steam. Uses electricity as an external heat source to change water to steam.

It shall have the following features:

- Tubular elements consisting of helical coil of 80% Nickel 20% Chromium alloy resistance wire in fushion welded to the nickel-coated steel terminal is used.
- Water tank made out of SS-304 sheet
- 25mm thick fiberglass insulation cladded with G.I./Aluminum sheet.
- In wall mounting, Floor mounting design as required.
- One bank of Heater is kept “ON” when the AHU is in operation to maintain the water temperature between 60-70 ºC
- Other bank to get “ON” upon signal from humidistat.

Control & Safeties to be required:

- Electronic water level sensor
- Float valve for water make up.
- Sight Glass
- Thermostat
- Safety stat.

It should have the following essential features:

- Built in safeties
- Easy & quick interlocking with AHU and humidistat.
- Complete package with all plumbing & electrical works done & factory tested.
- Automatic water recycling device.
- Manual reset thermal cutout
- Water level indicator
- BMS Compatible

PAN TYPE HUMIDIFIERS CAPACITIES SHALL BE

Technical Parameters

Power (KW)	Electrical Supply		Voltage (V)	No. of Elements	Steam Outlet	Dimensions			BTU/HR
	Amp	Main Swt Rating				L	W	H	
1.5	2	6	415	3	1 x 1.5"	725	275	250	5120
3.0	4	6	415	3	1 x 1.5"	725	275	250	10230
4.5	7	10	415	3	1 x 1.5"	725	275	250	15350
6.0	9	16	415	3	1 x 1.5"	725	275	250	20470
7.5	11	16	415	3	1 x 2"	825	275	250	25350
9.0	13	20	415	3	1 x 2"	825	275	250	30710
12.0	17	25	415	6	1 x 2"	825	350	325	40950
15.0	22	32	415	6	1 x 2"	825	350	325	51180
18.0	26	40	415	6	1 x 2"	825	350	325	61420

14. COIL MOUNTED ULTRAVIOLET (UVC) IRRADIATION SYSTEMS AS (optional item , IF SPECIFIED IN BOQ)

General Requirements:

Supply Installation of Emitters systems suitable for mounting on AHU / TFA / TFA CUM HRW to reduce Mold & fungus growth on the coil surface clean eliminating need for coil cleaning.

a. The UVC Lamp and reflective fixture will be factory assembled and tested. The power source for the lamp is housed in an aluminum enclosure that will mount separately.

b. The UVC source is a high output, low-pressure (3.0 Torr.) mercury laden argon-neon type that is internally coated to reduce the effects of solarization which would typically reduce output and have a bearing on overall lamp performance and life. The UVC source is a pure fused quartz type 219 shell, properly doped with Titanium Oxide in order to filter out 99.999% of the 185 nm wavelength to avoid the production of ozone.

c. To effectively irradiate the coil surface and drain pan, the UVC source shall be mounted on a geometrically adequate, parabolic shape, back-reflector to redirect at least 90% of the total emitted UVC onto the coil that will continuously clean the coil and drainpan, and kill odor causing mold and fungus that may develop in an HVAC unit.

d. The reflector will be built from a heavy single piece anodized aluminum extrusion, aerodynamically shaped to be capable of withstanding fast air velocities up to 2000 fpm without wobble, vibrations or noisy whistle.

e. In order to guarantee the adequate performance for a given coil, the vendor shall specify in detail, a manufacturer-approved layout of the number of UVC sources required, their respective position (distance from the coil and alignment on the coil). Adequate performance is defined by the IUVA (International Ultraviolet Association) guidelines as the irradiation intensity required so that a bacteria requiring a lethal UV dose of 100,000 microwatts/cm^2 will not survive more than 60 minutes anywhere on the surface of the coil. In order to validate the performance of the proposed arrangement, the vendor shall submit a manufacturer approved computer simulation showing the resulting bacteria kill – time map of the coil.

f. The power source will be an electronic type, rapid start with a power factor greater than 0.95 and an energy conversion of at least 75% and have an output matched to the length of the UV lamp. The power source will be protected from the air stream impurities by an adequate aluminum enclosure that

will enable it to be mounted on a rigid surface by way of screws. It shall be available in 110V or 208/230V AC and be able to operate reliably in environments ranging from 35ºF to 170ºF temperature, with relative humidity up to 100% and air velocities up to 2000 fpm. The power source will carry a 5-year corrosion warranty. The UVC net output directed at the coil is at least 10 microwatts/cm^2 per inch of lamp at 1 meter in the 245 nm to 266 nm band while operating in a 35ºF air stream moving at 1000 fpm.

g. Electrical Requirements: Will depend on Lamp length and input voltage.

h. Each UVC source will be clamp-mounted for easy installation, positioning and maintenance onto a ¾ inch anodized aluminum tube which is supplied by the manufacturer, or field supplied if longer than 70 inches as a permanent support structure. The support structure will field installed and be adequately fixed with non-corrosive hardware so that the UVC source does not vibrate or loosen.

i. According to the 2008 ASHRAE Handbook, HVAC Systems and Equipment, Chapter 16, titled Ultraviolet Lamp Systems, UVGI Systems can be installed Upstream or Downstream of the Cooling Coil. Both locations have advantages and disadvantages. It would be prudent to investigate which side of the coil provides the best installation for the application. If the installation is to mount the UVC source facing the coil on its return side thereby treating the coil at the earliest possible time, the parabolic reflector will act as a protector for the UVC source so that it remains clean from Lamp Fouling (dust, moisture, bio-aerosols) and protects the lamp from Lamp Cooling Effects, requiring a minimum of maintenance.

j. The UVC source (Lamp) will be guaranteed for 9,000 hours of operation.

15. ACCESSORIES

Each air handling unit shall be provided with manual air vent at high point in the cooling coil and drain plug in the bottom of the coil. In addition, the following accessories may be required at air handling units, their detailed specifications are given in individual sections, & quantities separately identified in schedule of Quantities.

a. Insulated butterfly valves, balancing valves, `Y' strainer, union & condensate drain piping with 'U' trap upto sump or floor drain in air handling unit room, as described in section "Piping".

b. Thermometers in the thermometer wells & pressure gauge (with cocks) within gauge ports in chilled water supply and return lines as per the section "Instruments".

16. SAFETY FEATURES:

All Floor Mounted AHU's / Ceiling Suspended AHU's / TFA's / HRW's shall have:

a. Limit switch for door interlock i.e. fan to trip automatically on opening of access door and shall be completely wired up (both for floor mounted and ceiling suspended AHU's / TFA / TFA CUM HRW). Door limit switch shall be double throw type (2 Poles) rated for 230 V, AC, 5A.
b. Marine light (Except for Ceiling Suspended AHU's). It shall be LED type & IP 55 rated. It shall turn ON only when AHU door is opened, otherwise it will remain OFF.
c. UV light if called for in the BOQ including complete internal wiring & interlocking with door opening, light to shut off automatically on door opening.
d. ESP filter will be ON only if AHU is running.
e. Glass view window.
f. Fan and motor base shall be properly earthed from the factory.
g. All screws used for panel fixing, projecting inside the unit shall be covered with PVC caps to avoid human injury.

17. HEAT RECOVERY WHEEL SECTION (OPTIONAL ITEM, IF ASKED FOR IN THE BOQ)

This shall be provided by the AHU supplier of the specified make given in the list of make & technical specification as given below for 100% fresh air TFA AHU with HRW as per Bill of Quantities.

The Heat Recovery Wheel (HRW) is based on the concept of both sensible & latent heat recovery between two air streams using corrugated aluminium media rotor synthesized with selective absorbent, suitable for selective transfer of water vapour.

Principle of Operation of HRW

The HRW or rotor slowly rotates between two air streams i.e. outdoor & return air streams. The higher temperature air stream gives up its sensible heat to aluminium (rotor media). The energy is then transferred to the cooler air stream, during the second half of the rotation. Similarly the moisture (latent heat) is transferred from high humidity stream to the low humidity air stream with the help of desiccant coating provided on the aluminium surface. This is so because the desiccant coating provided has very large internal surface area & a very strong affinity to the water vapour. Since the opposing air stream have different temperature & moisture contents, their vapour pressure differ. This vapour pressure differential serves as the sole driving force which promotes the transfer of latent energy.

The Substrate for HRW

The substrate or wheel matrix should be only of pure aluminum foil so as to allow the following:

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.

Nonmetallic substrates made from paper, plastic, synthetic or glass fibre media, will not be acceptable.

The substrate shall not be made from any material which is combustible or supports combustion.

The Desiccant for HRW

The desiccant should be water molecule selective and non-migratory.The desiccant should be of "**Ecosorb 340**" type, which combines the selectivity of a 3Å molecular sieve desiccant for the 2.8A water molecules, and has the higher diffusivity of the 4Å molecular sieves, so as to ensure the exclusion of contaminants in the air stream, while transferring only water vapour molecules, resulting in selective and fast latent recovery.

The desiccant, of sufficient mass, should be coated with non masking porous binder adhesive on the aluminum substrate so as to allow quick and easy uptake and release of water vapour. A matrix with desiccants impregnated in non-metallic substrates, such as synthetic fibre, glass fibre, etc. will not be accepted.

The rotor/wheel matrix shall have equal sensible and latent recovery.

The weight of desiccant coating and the mass of aluminum foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range. Accordingly, a rotor matrix which has an etched or oxidized surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fibre matrix which result in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

The Rotor for HRW

With optimum heat and mass through matrix formed by desiccant, of sufficient mass, coated on an aluminum foil, 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 shall be made of alternate flat and corrugated aluminum foil of uniform width. 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 up to 2800 mm shall have spoken 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 minimizing the leakage/drag on the radial seals, and minimize the fluctuation in the tension of the drive belt.

The number of wraps (of alternative corrugated and flat foil) 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 rotor shall be a non-clogging aluminum media, having a multitude of narrow aluminum foil channels, thus ensuring a laminar flow, and will allow particles upto 800 microns to pass through it.

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

The Cassette / Casing of HRW

The recovery wheel cassette/casing shall be manufactured from tubular structure to provide a self-supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt. The drive motor shall be suitable for 3phase,50Hz, 415V power supply.

Purge System In HRW

The rotor / wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants from the exhaust air to the supply air. It shall be possible with proper adjustments to limit cross contamination to less than 0.4 % of that of exhaust air concentration.

The face and radial seals shall be four pass non contact labyrinth seals for effective sealing between the two air streams and also for minimum wear and tear ensuring infinite life of seals.

Efficiency of HRW: Total efficiency of Heat Recovery Wheel shall not be less than 75%, both on sensible & latent heat recovery.

- Wheel shall be AHRI certified for performance & air pressure drop.

18. ISOLATORS

Vibration isolators shall be provided with all air handling units for installation on foundation/plinth. Vibration isolators shall be cushyfoot mounting type. Minimum vibration isolation efficiency shall be 90%.

19. PAINTING

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

20. PERFORMANCE DATA

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

21. TESTING

Cooling capacity of various air handling unit models be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated mercury- in-glass thermometers. Computed results shall conform to \ the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current.

21a. TESTING AT WORKS – OPTIONAL IF SPECIFIED IN BOQ.

Factory performance testing to establish the cooling capacity of the unit, air flow rate , dry bulb and wet bulb temperatures of air entering and leaving the coil of the air handling unit using PLC controlled graphical display. All the results must be fully computerized and can be seen on real time basis.

The testing setup shall be in accordance with DIN EN 14511.

Minimum 4 hours continuous real time readings should be recorded for computation of operational parameters.

Additionally, electrical safety Hi-pod testing, dry run testing for control logic, thermal bridging test and leakage testing of cabinet at works must be complied with as part of performance test of the air handling unit.

22. CODES & STANDARDS

The design, materials, manufacture, inspection, of the AHU's shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the equipment is to be installed. In particular, the AHU's shall conform to the following standards & All items as listed below shall be certified and marked with the following standards :

AHRI 410	Air Cooling and Air Heating Coils for performance / capacity & water & air side pressure drops.
BS EN 1886	Mechanical & thermal performance of casing
IEC 60204-1 :2005 / EN 60204-1:2006	Safety of machinery – electrical equipment of Machines part 1 general requirements.
AMCA	Fans / Blowers for performance & sound.
AHRI	Heat Recovery wheel for performance & air pressure drop.

AHU casing should be certified as per EN -1886 standard. The units should confirm the following parameters:

Mechanical strength of casing	Class 2A
Casing air leakage	Class B
Filter by -pass leakage	Class 9
Thermal Transmittance	T1
Thermal bridging	TB2

23. TOTAL STATIC PRESSURE & EXTERNAL STATIC PRESSURE

Contractor / Equipment manufacturer to calculate total static pressure (TSP) in mm Wg by adding ESP & internal static pressure of the unit. TSP selected should be such that under all operating conditions, the designed ESP & CFM (duty parameter) is delivered.

24. MODE OF MEASUREMENT:

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

2.0 AIR HANDLING UNIT / TREATED FRESH AIR UNIT / TFA CUM HRW UNIT

Air handling unit / Treated fresh air unit TFA cum HRW unit with / without coil with flexible connection at fan outlet to AHU / TFA casing & AHU / TFA casing to Duct / Plenum, filter(s)/gas phase filteration , fan, cooling /heating Coils, HRW, motor, outlet damper, vibration isolators etc., as specified in tender document shall form one unit for the purpose of measurement and payment.

25. **TECHNICAL REQUIREMENTS**

Sl. No.	Description	Requirements
1	Numbers and minimum capacity	Refer equipment schedule / BOQ
2	Cooled and Dehumidified air flow rate –	Refer schedule / BOQ
3	Cooling coil face area	Air velocity across cooling coil face area to be less than 2.54 m/s (500 FPM)
4	Number of rows for cooling coil	4 / 6 / 8 as per BOQ
5	Entering chilled water temperature – deg F	As per BOQ
6	Leaving chilled water temperature – deg F	As per BOQ
7	Chilled water flow rate – GPM	Refer schedule / BOQ
8	Drain connection on both sides of AHU	50 mm dia socket connection or as per manufacturer design
9	Cooling Coil tube dia & thickness	12.7 mm to 15 mm / 0.5 mm for water coils & 9.52 mm /0.5mm for Dx coils
10	No. of Fins	12 FPI
11	Fan outlet Velocity	Not more than 9.2 m/s (1800 FPM)
12	Type of fan motor	Sq.cage Induction AC motor
13	Pre-filters (MERV 8)	The efficiency of the filters shall be 90%down to particle size of 10 microns as per IS 7613, and ASHRAE 52.2.
14	Fine filters (MERV 14)	The efficiency of the filters shall be 99% down to particle size of 3 microns as per IS 7613 and ASHRAE 52.2
15	Fine filters (MERV 14)	The efficiency of the filters shall be 95% down to particle size of 1 microns as per IS 7613 and ASHRAE 52.2
16	Noise level	Not exceeding 68-70 db @ a distance of 1M from all corners / sides of AHU.

26.

DATA SHEET - A
DATA TO BE FURNISHED BY TENDERER
(For each size / capacity of AHU separately)

Sl. No.	DESCRIPTION	REQUIREMENT
1.	Air Handling Unit No.	
2.	Type	
3.	Model / Make	
4.	Grand Total Heat (TR)	
5.	Total Sensible Heat (TR)	
6.	Minimum Supply Air Quantity (S/A – CFM)	
7.	Minimum Outside Air Quantity (O/A – CFM)	
8.	Air entering coil temperature (DBT _____°F, _____WBT °F)	
9.	Air entering coil temperature (DBT _____°F, _____WBT °F)	
10.	Air leaving coil temperature (– DB deg F)	
11.	Air leaving coil temperature (– WB deg F)	
12.	Maximum Air Face Velocity (FPM) across coil	
13.	Maximum Air side pressure drop across coil (mm wg)	
14.	Total Fan Static Pressure (mm wg)	
15.	External Static Pressure (mm wg)	
16.	Chilled Water Entering Coil Temperature (deg F)	
17.	Chilled Water Leaving Coil Temperature (deg F)	
18.	Chilled Water Velocity – Maximum (FPM)	
19.	Coil Rows	
20.	Coil Fins / Inch.	
21.	Chilled Water Flow Rate in gpm	
22.	Maximum Chilled Water Pressure Drop (m) through coil	
22.1	Type of Fan	
22.2	Type of Fan Control	
22.3	Maximum fan rpm	
22.4	Maximum outlet velocity	
23.	Type of Filters	
24.	Pre filters : Numbers Dimension Efficiency Face velocity	
25.	Fine Filters: Numbers	

DATA SHEET - A
DATA TO BE FURNISHED BY TENDERER
(For each size / capacity of AHU separately)

Sl. No.	DESCRIPTION	REQUIREMENT
	Dimension Efficiency Face velocity	
26.	Maximum Air side pressure drop across filter (mm wg)	
27.	Type of Starter	
28.	Motor Voltage	
29.	Type of Vibration isolator	
30.	Interlock with smoke detector and fire alarm system	
31.	Supply and return air noise treatment	
32.	Controls	
33.	Dimensions L x B x H	
34.	Operating weight kg	
35.	AHU motor kW rating	

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DATA SHEET - C

DATA TO BE FURNISHED BY THE CONTRACTOR AFTER THE AWARD OF CONTRACTOR AND BEFORE INSTALLATION

1. Schedule of drawings and documents to be submitted for review, approval and information with submission dates.

2. Quality Assurance Plan (QAP).

3. Detailed P & I diagram showing clearly the scope of supply of equipment, piping with line sizes and material specifications, specialities, instrumentation and control and all accessories. This drawing or documents mentioned under following clauses shall include all design data and information furnished in data sheets A and B. The makes of all major components and controls shall be indicated.

4. Dimensioned general arrangement drawing showing all equipment with accessories, mounting details, nozzle locations, etc.

5. Overall space and headroom requirement with details of handling during erection, operation and maintenance.

6. Foundation drawing with static and dynamic loading data, pocket details, foundation outline, etc, for all items.

7. Cross-sectional drawings of all items with part list and materials of construction.

8. Performance curves and selection charts for fan, filters, etc. Selection charts and calculation for cooling coil.

9. Operation and maintenance manual with lubrication schedule.

10. Catalogues furnishing detailed technical data for fan, coils, filters, etc.

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DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

Air Handling Unit No: -

Sl. No.	Description	Unit	Remarks
1.	Entering Air temp DB (deg F)		
2.	Entering Air temp WB (deg F)		
3.	Leaving Air temp DB (deg F)		
4.	Leaving Air temp WB (deg F)		
5.	Entering Water temp (deg F)		
6.	Leaving Water temp (deg F)		
7.	Coil / Filter area (SFT)		
8.	Face Velocity (FPM)		
9.	Air Flow (CFM)		
10.	Fan Speed (RPM)		
11.	Voltage		
12.	Current (A) = R- Phase		
	= Y- Phase		
	= B- Phase		
13.	Over load relay range A		
14.	Over load relay setting A		
15.	Inlet Water pressure (Kg / cm^2)		
16.	Outlet water pressure (Kg / cm^2)		
17.	Noise level AHU room (dBA)		
18.	Vibration level (Microns) = X - axis		
	= Y - axis		
	= Z - axis		
19.	Fresh air velocity (FPM)		
20.	Fresh air filter area (SFT)		
21.	Fresh air flow (CFM)		
22.	Designed CFM		

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DATA SHEET - D

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

Air Handling Unit No: -

Sl. No.	Description	OK	Needs Attention	Not Applicable	Remarks
Outside Air Intake					
1.	Location				
2.	Open during occupied hours?				
3.	Unobstructed				
4.	Odours from outdoors? (Describe)				
5.	Cooling tower within 25 feet?				
6.	Exhaust outlet within 25 feet				
Bird Screen					
7.	Unobstructed?				
8.	General condition?				
Outside Air Dampers					
9.	Operation acceptable?				
10.	Seal when closed?				
11.	Actuators operational?				
12.	Minimum % O.A				
13.	Measured % O.A *Note day, time, HVAC operating mode under "Comments"*				
14.	Maximum % O.A				
15.	Is minimum O.A. a separate damper?				
16.	For VAV systems: is O.A. increased as total system airflow is reduced?				
Mixing Plenum					
17.	Clean?				
18.	Floor drain trapped?				
19.	Air tightness				
20.	ᵥof outside air dampers				
21.	ᵥof return air dampers				
22.	ᵥof exhaust air dampers				
23.	All damper motors connected?				

Sl. No.	Description	OK	Needs Attention	Not Applicable	Remarks
24.	All damper motors operational?				
25.	Air mixers or opposed blades?				
26.	Mixed air temperature control setting ---------- °F				
27.	Is mixing plenum under negative pressure? *Note: If it is under positive pressure, outdoor air may not be entering.*				
Filters					
28.	Type				
29.	Complete coverage? (i.e., no bypassing)				
30.	Correct pressure drop? (Compare to manufacturer's recommendations.)				
31.	Contaminants visible?				
32.	Odour noticeable?				
Spray Humidifiers or Air Washers					
33.	Humidifier type				
34.	All nozzles working?				
35.	Complete coil coverage?				
36.	Pans clean; no overflow?				
37.	Drains trapped?				
38.	Biocide treatment working? *Note: Is MSDS on file?*				
39.	Spill contaminant system in place?				
Cooling Coil					
40.	Inspection access?				
41.	Clean?				
42.	Supply water temp.--------- °F				
43.	Water carryover?				
44.	Any indication of condensation problems?				
Condensate Drip Pans					
45.	Accessible to inspect and clean?				
46.	Clean, no residue?				
47.	No standing water, no leaks?				

Sl. No.	Description	OK	Needs Attention	Not Applicable	Remarks
48.	Noticeable odour?				
49.	Visible growth (e.g., slime)?				
50.	Drains and traps clear, working?				
51.	Trapped to air gap?				
52.	Water overflow?				
Supply Fan Chambers					
53.	Clean?				
54.	No trash or storage?				
55.	Floor drain traps are wet or sealed?				
56.	No air leaks?				
57.	Doors close tightly?				
Supply Fans					
58.	Location				
59.	Fan blades clean?				
60.	Belt guards installed?				
61.	Proper belt tension?				
62.	Excess vibration?				
63.	Corrosion problems?				
64.	Controls operational, calibrated?				
65.	Control sequence conforms to design / specifications? (Describe changes)				
66.	No pneumatic leaks?				
Steam Humidifier					
67.	Humidifier type				
68.	Treated boiler water				
69.	Standing water?				
70.	Visible growth?				
71.	Mineral deposits?				
72.	Control set point ---------- ºF				
73.	High limit set point ---------- ºF				
74.	Duct liner within 12 feet? (If so, check for dirt, mold growth.)				

SUBHEAD-D. Duct Mounted Air Purification Pentagon

S.No.	Description	Details
1.	**Advanced Oxidation Plasma Cell**	The AOP cells to be installed preferably in the supply air stream/ plenum of AHU in accordance with the AHU capacity to take care off in respect of air borne contamination (bacteria, virus and spores), Gaseous contamination (VoC's & Odors) along with particulate matter with-in built pest repellant to drive away the rodents away. Unit selection sheet and load calculation to be submitted.
2.	**Air Flow Type:**	The AOP cells to be installed in air duct supporting a longitudinal/transverse/parallel air flow depending upon the requirement and easy accessibility.
3.	**Air Flow Direction:**	Towards Lamp .
4.	**Lamp Assemblies Shape:**	Pentagon.
5.	**UV lamp & life :**	254 UVC lamp. Broad spectrum lamp 100-380 nm shall not be accepted. The lamp shall be replaced after 2 years.
6.	**Ballast, Wire Sets connecting Air Purifier, Lamp/ Lamp Holder, Bushing and Powercord**	The components of the equipment shall be certified by CE , ISO, RoHS. All relevant certifications to be submitted along with the technical data sheet, failing which it shall not stand qualified.
7.	**Indicator**	There will be one ballast, three indicators for each lamp that will show whether the AOP Cell is ON/OFF. The unit is designed to run 24x7.
8.	**ELECTRICAL ELEMENTS**	The ballasts will be instant start, solid state electronic type, 220V/50 Hz.
9.	**Power Consumption:**	Upto 6500 CFM –24V AC - 21 Watts 6500 - 20000 CFM –24V AC - 36 Watts 20000 - 28000 CFM –24V AC - 48 Watts
10.	**INSTALLATION:**	Preferably Supply duct/ plenum otherwise Return duct.
11.	**Lamp:**	The maximum length of lamp shall be around 18 inches.
12.	**PERFORMANCE:**	The AOP cell technology features a UV lamp and rare metallic target that combine to generate nature's friendly oxidizers like ionized hydroxyl's.
13.	**Test Result with Certification**	1. SARS COV 2 ICMR/ CCMB certification with reduction greater than 99 percent within 45 mins; 2. H1N1 certification with reduction greater than 99 percent within 30 mins; 3. MS-2 Virus Certificate; 4. ICMR/ IIT – Human Safety certificate;

		5. No Ozone certificate from an International Third Party Lab; 6. CE , ISO, ROHS & FDA; 7. Green Pro Certification;
14.	**SELECTION**	The detailed selection chart vis-à-vis each application and CFM shall be submitted for approval, indicating model number and number units for each CFM.

SUBHEAD-E. VENTILATION FANS

1. SCOPE

The scope covers Design, Supply, Installation, testing & Commissioning of Basement Ventilation system, Pressurization system, Smoke Venting System and MEP room's ventilation as per Latest National Building Codes & Fire Department's NOC.

The specification for supply & exhaust air fans / blowers for mechanical ventilation covers the design requirement, constructional feature, supply, installation, testing & commissioning of complete Ventilation, Smoke Venting & Pressurization.

2. TYPE

The fan / blower shall be of Vane Axial / Tube Axial Flow fans / Centrifugal Fans / Cabinet Fans / Inline fans / Propeller Fans with or without ducting system & shall be of floor mounted / wall mounted / ceiling hung type as called for in the Schedule of Quantities.

3. CAPACITY

The capacity of Vane Axial / Tube Axial Flow fans / Centrifugal Fans / Cabinet Fans / Inline fans / Propeller Fans, diameter, maximum motor H.P & static pressure etc. shall be according to schedule of quantities. Fans shall be selected for maximum efficiency and lowest noise levels.

Fans shall be AMCA listed & certified for both air performance & inlet sound power level.

4 VANE AXIAL / TUBE AXIAL FLOW FANS

The Fan / air blower shall be Vane Axial / Tube Axial Flow fan connected to the duct /wall/shaft shall be of floor / ceiling / wall mounted type as specified in the Bill of Quantities. The capacity of Vane axial / Tube axial / flow fans, diameter, maximum motor H.P & static pressure etc. shall be according to schedule of equipment & Bill of Quantities.

a. The cylindrical casing should be made from continuously welded galvanized steel or mild steel. IF GSS is used for casing, then the sheet should be of minimum 220 gsm coating. And if MS casing is used, then it should be either hot dip galvanized or to be primer coated & finished with powder coating. The inlet & outlet of the casing shall be fitted with flanges for ductwork connection & other accessories as required. The surface finish shall be epoxy coated. The blade of axial flow fan shall be made of die cast aluminium alloy. The blade angle shall be set at manufacturing place & shall also have facility to modify latter. The hub shall consist of two half-hubs pressed in carbon steel & the centre boss shall be made of die-cast aluminium alloy. The blade feet shall be locked in two half - hubs. The impeller assembly shall be fixed on the shaft by means of a double cone type expansion bush. The design shall facilitate the alteration of blade angle without disconnecting the hub from the motor shaft. The blades shall be of aerofoil design. The fan shall be directly driven by TEFC sq. cage induction motor. Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz. The motor shall be specially designed for quiet operation & motor RPM shall be as given in Bill of Quantities. Fan motors shall be IE2/IE3/IE4 efficiency as specified in the schedule of quantities. After assembling the impeller shall be statically & dynamically balanced as per AMCA 204-05 standard to a minimum of BV-3 Level.

Fan's meant for Exhaust/Smoke exhaust shall be suitable to with stand a temperature of 250 deg C for 2 hours. The fan and motor of such fans shall be designed to operate at such a high temperature without any failure and duty deration. The fan casing, impeller and rotor shall be designed to with stand this high temperature and smoke. The motor, its terminal box and connecting power lead shall be suitable for fire and smoke duty of 250 deg C temp for 2 hours. High temperature fans shall be UL or EN Certified in addition to AMCA certified & listed. Motors shall be TEOA, Squirrel cage induction motors, IP55, Class H insulation, suitable for 415±10% V and 50±5% Hz totally enclosed, non-ventilated type. Motor shall be IE2 /IE3/IE4 efficiency as mentioned in the schedule of quantities.

The mounting ring shall be of CRCA / sheet steel with brackets to connect the frame, with the Fan / Motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting

brackets.

5. CENTRIFUGAL FANS – CABINET FANS FOR MEP ROOMS VENTILATION

A. DOUBLE SKIN CABINET TYPE CENTRIFUGAL FANS – SUPPLY AIR

- Fan cabinet shall be manufactured in galvanized sheet steel incorporated with a belt driven, high efficiency, low noise level, DIDW forward, backward or backward Aero foil impeller as called for in the BOQ.
- Fan Cabinet shall be double skin.
- Fan & Cabinet shall be of G.S.S., the Steel sheet should be JFE Galvazinc (Base metal cold rolled), JIS G3302, SGCC with Z22 (minimum coating weight on both sides @ 220 g/m2) zinc coating.
- Fan motor shall be Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz., 3 Phase supply. Motor shall be designed for quiet operation. Fan motor efficiency IE2/IE3/IE4 as specified in the schedule of quantities. It shall be complete with V-Belt drive package.
- Centrifugal fan inside the cabinet shall be certified from AMCA for AIR, SOUND & FEG. Fan efficiency shall be as per FEG-71.
- Fresh air filter section MERV-7/8, cleanable, synthetic non woven filter with aluminium frame, if called for in the BOQ.

B. DOUBLE SKIN CABINET TYPE SMOKE SPILL CENTRIFUGAL FANS – EXHAUST AIR

- Fan cabinet shall be manufactured in galvanized sheet steel incorporated with a belt driven, high efficiency, low noise level, DIDW forward, backward or backward Aero foil impeller as called for in the BOQ.
- Fan Cabinet shall be double skin.
- Fan & Cabinet shall be of G.S.S., the Steel sheet shall be JFE Galvazinc (Base metal cold rolled), JIS G3302, SGCC with Z22 (minimum coating weight on both sides @ 220 g/m2) zinc coating.
- Motor shall be with 'F' class insulation & IP55 protection with high efficiency, Drive setup (Belt, Pulley & Motor) should be outside the air / smoke flow path. Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz., 3 Phase supply. Motor shall be designed for quiet operation. Fan motor efficiency IE2/IE3/IE4 as specified in the schedule of quantities. It shall be complete with V-Belt drive package.
- The entire unit (DIDW fan with double skin cabinet) shall be tested in accordance to standard 'BSEN12101-3:2002', complies with the performance criteria for 400ºC at 2 Hours and certified Tested by any internationally recognized laboratory, Fire Test certificate of fans should be submitted with submittal.
- All the supplied models shall be mentioned in the fire test certificate for 400ºC at 2 Hours.
- Centrifugal fan inside the cabinet shall be certified from AMCA for AIR, SOUND & FEG. Fan efficiency shall be as per FEG-71.

6. PROPELLER FANS

The Propeller Fan blades shall be pressed steel of aerofoil design for high fan efficiency and static pressure. The blades shall be riveted to a central steel hub. The motor and blades assembly shall be mounted in a cast iron / sheet steel frame with steel brackets. Rubber mounts shall be provided between the mounting frames and brackets. The fan motor shall be totally enclosed type. Fan shall be statically and dynomatically balanced with pre-lubricated double ball bearing. Single phase fan to be with start and run capacitors.

7. IN-LINE FANS

Inline fans shall be complete with centrifugal impeller, casing, direct driven motor, vibration isolators, direction of discharge and rotation position shall be as per the job requirement and shall be marked on the fan assembly. Housing shall be constructed of hot rolled GSS sheet metal construction. Housing metal parts shall be either spot-welded or screwed or mounted together with rivets. Indication showing rotation arrow and make, model number and duty conditions of the fan shall be available on the housing. Fan wheel shall be forward curved type, statically and dynamically balanced. The fan shall be provided with ball bearings can be used in any mounting position at maximum indicated temperature.

8. BASEMENT / PODIUM VENTILATION/ DG ROOM VENTILATION FANS:

SUPPLY & EXHAUST AIR FANS

Type of Fans:

a. Supply Air Fans:

i. Vane Axial

ii. Tube Axial

b. Exhaust Air Fans:

i. Vane Axial

ii. Tube Axial

c. **Normal Time ACPH :** 6 ACPH (Supply Air & Exhaust Air)

d. **Smoke Time ACPH :** 6 ACPH + 6 ACPH = 12 ACPH (Supply Air & Exhaust Air)

For the sake of inter changeability, we may consider both 6+6 ACPH (Normal & Smoke time) fans of same type.

e. **Supply Air Fan (For both 6 ACPH + 6 ACPH) : VANE AXIAL**

i. 960 RPM max.

ii. Minimum Total Efficiency as per FEG71

iii. As per FEG (Fan Efficiency Grade) 71 as per AMCA

iv. Noise level not more than 75-78dbA @3m distance.

v. Fan outlet velocity : 12-15 m/sec max.

vi. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below

vii Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

viii Fans shall be AMCA Certified & listed for performance & sound power level.

e1. **Supply Air Fan (For both 6 ACPH + 6 ACPH) : TUBE AXIAL**

i. 960 RPM max.

ii. Minimum Total Efficiency as per FEG63

iii. As per FEG (Fan Efficiency Grade) 63 as per AMCA

iv. Noise level not more than 78 - 80dbA @3m distance.

v. Fan outlet velocity : 12-15 m/sec max.

vi. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below

vii Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.

viii Fans shall be AMCA Certified & listed for performance & sound power level.

f. **Exhaust Air Fan (For both 6 ACPH + 6 ACPH) : VANE AXIAL**

i. 960 RPM max.

ii. Minimum Total Efficiency as per FEG71

iii. As per FEG (Fan Efficiency Grade) 71 as per AMCA

iv. Noise level not more than 75-78dbA @3m distance.

v. Fan outlet velocity : 12-15 m/sec max.

vi. Suitable for 250°C for 2 hrs. operation. Fire Rated

vii. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below

viii Motors shall be TEOA, Squirrel cage induction motors, IP 55, Class H insulation, suitable for 415±10% V and 50±5% Hz.

ix Fans shall be AMCA Certified & listed for performance & sound power level.
x Fans for high temp. application shall be UL or EN Certified in addition to AMCA certified & listed

f1. **Exhaust Air Fan (For both 6 ACPH + 6 ACPH) : TUBE AXIAL**
i. 960 RPM max.
ii. Minimum Total Efficiency FEG63
iii. As per FEG (Fan Efficiency Grade) 63 as per AMCA
iv. Noise level not more than 78 - 80 dbA @3m distance.
v. Fan outlet velocity : 12-15 m/sec max.
vi. Suitable for 250°C for 2 hrs. operation. Fire Rated
vii. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below
viii Motors shall be TEOA, Squirrel cage induction motors, IP 55, Class H insulation, suitable for 415±10% V and 50±5% Hz.
ix Fans shall be AMCA Certified & listed for performance & sound power level.
x Fans for high temp. application shall be UL or EN Certified in addition to AMCA certified & listed

Note: Vane Axial is preferable over Tube Axial fan as its more efficient and less noiser than tube axial fan for basement/podium ventilation.

B. PRESSURIZATION FANS
i. Staircase Pressurization
ii. Lift Lobby Pressurization
iii. Lift Well Pressurization

Type of Fans for Pressurisation:
i. Tube Axial
ii. 1440 RPM max.
iii. Noise Level 85dbA or slightly more @3m distance.
iv. Fan outlet velocity : 15-18 m/sec max. (Not exceeding 18 m/sec)
v As per FEG (Fan Efficiency Grade) 63 as per AMCA
vi Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.
viii Fans shall be AMCA Certified & listed for performance & sound power level.

C. SMOKE VENTING FANS:
i. Smoke Venting of Corridors
ii. Smoke Venting of Atrium
iii. Smoke Venting of Office Floors

Type of Fans for Smoke Venting:
i. Tube Axial
ii. 1440 RPM max.
iii. Noise Level 85dbA or slightly more @3m distance.
iv. Fan outlet velocity : 15-18 m/sec max. (Not exceeding 18 m/sec)
v. Suitable for 250°C for 2 hrs. operation (Fire rated)
vi As per FEG (Fan Efficiency Grade) 63 as per AMCA
vii Motors shall be TEOA, Squirrel cage induction motors, IP 55, Class H insulation, suitable for 415±10% V and 50±5% Hz.
viii Fans shall be AMCA Certified & listed for performance & sound power level.

ix Fans for high temp. application shall be UL or EN Certified in addition to AMCA certified & listed

D. MEP ROOM VENTILATION FANS

i. AC Plant Room
ii. Pump Room
iii. LT Panel Room
iv. HT Panel & Transformer Rooms
v. STP Room

Type of Fans for MEP Rooms Ventilation:

a. Supply Air Fan :

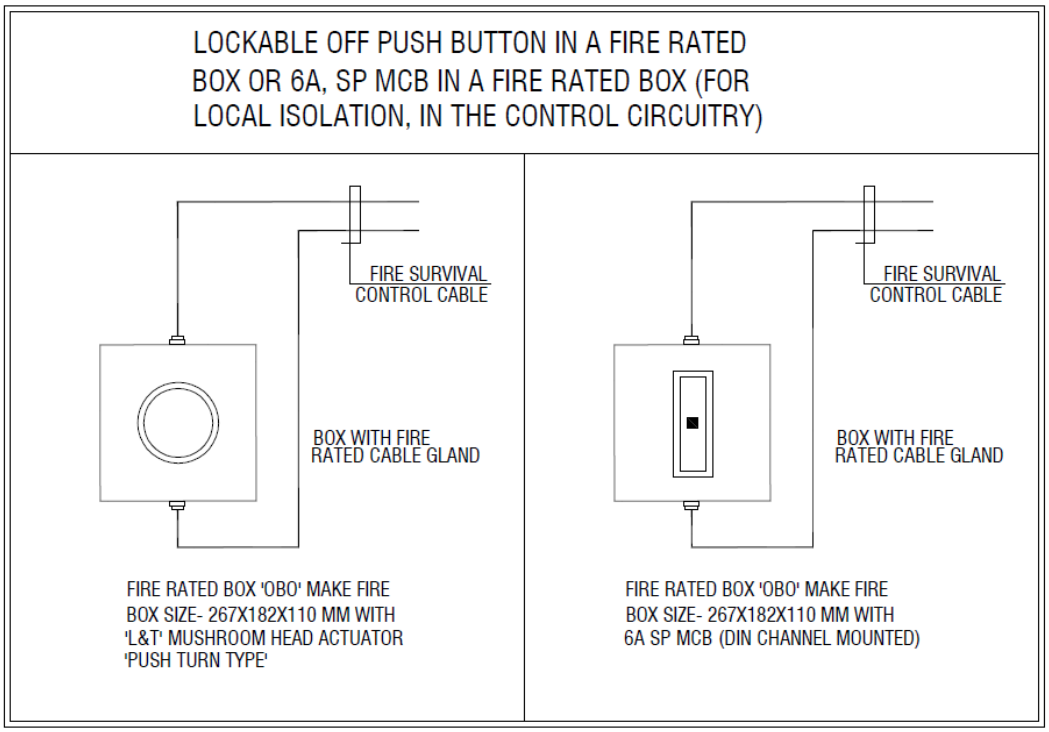
i. Cabinet Fan section - DIDW Fan
ii. Ceiling Suspended / Floor Mounted
iii. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below
iv. As per FEG (Fan Efficiency Grade) 71 as per AMCA
v Motors shall be TEFC, Squirrel cage induction motors, IP 55, Class F insulation, suitable for 415±10% V and 50±5% Hz.
vi Fans shall be AMCA Certified & listed for performance & sound power level.
vii Fan shall be complete with MERV-8 pre-filter.

b. Exhaust Air Fan (Smoke Spill Fan) for MEP rooms :

i. Cabinet Fan section - DIDW Fan
ii. Fire Rated Fan (250°C for 2 hrs.) (Smoke Spill Fan)
iii. Motor & Belt Outside Air Stream
iv. Ceiling Suspended / Floor Mounted
v. Motor Efficiency Class: IE2/IE3/IE4 as per IEC 60034-30-1, as specified below
vi. Motors shall be TEOA, Squirrel cage induction motors, IP 55, Class H insulation, suitable for 415±10% V and 50±5% Hz.
vii As per FEG (Fan Efficiency Grade) 71 as per AMCA
viii Fans shall be AMCA Certified & listed for performance & sound power level.

9. Local Electrical Isolation:

All Fans shall be provided with Lockable off push buttons / isolators for local isolation as the case may be.



10. Accessories: As listed below to be considered as part of the fan assembly and inclusive of fan cost:

a. Dunlop cushy foot vibration isolators / spring isolators for the blowers / tube / vane axial fans.

b. Double canvas connections, fire retardant type, at the outlets / inlet of each fan.

c. Nuts, Bolts, Shims etc. as required for the grouting of the equipment

d. Slide rails for mounting the motor and belt adjustments.

e. Bird Screens in the Inlet and or outlet as the case may be for protection and safety.

11. Performance Data

All fans shall be selected for the lower operating noise level. Capacity ratings, power consumption, with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation. All the fans should be AMCA certified for sound and performance. Fan performance shall be based on tests conducted in accordance to AMCA 210 for air performance & AMCA 300 for inlet sound power levels. Fans shall be licensed to bear the AMCA seal for air & sound performance.

12. Testing

Capacity of all fans shall be measured by an anemometer. Measured airflow capacities shall conform to the specified capacities and quoted ratings. Power consumption shall be computed from measurements of incoming voltage and input current. Contractor has to carry out the field balancing, if required.

13. JET FANS FOR CAR PARK VENTILATION-HIGH TEMPERATURE/- DUAL SPEED"

SCOPE:

Ductless Ventilation system Package consists of:

1. Jet Vent Fan
2. CO Sensor
3. Control Panel for controlling Jet fan system
4. CFD analysis
5. Sequence of Operation

Jet Fans, Control panel, CO Sensors and related equipment shall be installed by the contractor as per CFD analysis.

The control system shall include as, a minimum, the control panel, CO sensor as indicated on the plans / in the BOQ. Provide additional items, if required to make the system perfect.

JET FANS :

a. AXIAL FLOW FAN TYPE:

The fan casing shall be heavy duty galvanized steel & impeller shall be made of PPG, PAG or aluminium. The fan shall be Axial Flow type. The casing shall be with mounting bracket / arrangement.

Motor shall be Class-H. Motor shall be two speed type.

Silencer's outer casing shall be made of galvanized steel & inner casing shall also be made of perforated galvanized steel sheet. Glass fibre absorption filer material to be used to achieve acoustic performance. Minimum 2D silencer or more to be used.

Complete fan & motor assembly shall be fire rated for 250°C for 2 hrs. Motors shall be TENV, Squirrel cage induction motors, IP 55, Class H insulation, suitable for 415±10% V and 50±5% Hz., totally enclosed, non-ventilated, suitable for 250 deg C for 2 hours of operation. Motor shall be two speed type.

The fan shall be AMCA certified & listed for performance & sound. Jet Fan shall be balanced dynamically and statically.

Alternatively fans shall be TUV SUD certified. And shall be tested in accordance with EN 12101-3: 2002 F400.

b. CENTRIFUGAL FAN TYPE:

The fan casing shall be galvanized steel with two mounting brackets.

The centrifugal fan shall be backward curved wheel in MS with polyester painting. The fan shall be complete with inlet guard.

The motor shall be Class-H insulation and shall be 2 speed motor. Motor shall be suitable for 415 ± 10% volts, 50 ±3% Hz. Motor shall be Squirrel cage induction motors, TENV, IP55, class H insulation, totally enclosed, non-ventilated type rated for 250 deg C for 2 hours operation.

The complete fan & motor assembly shall be fire rated suitable for working at 250°C for 2 hrs.

The fan shall be AMCA 211 & AMCA 311 certified & listed for performance & sound. Jet Fan shall be balanced dynamically and statically.

PERFORMANCE DATA

All fans shall be selected for the lowest operating noise power levels. Capacity ratings, power consumption, with operating points clearly indicated, shall be submitted and verified at the time of testing and commissioning of the installation. Jet fans should be AMCA certified & AMCA listed. High temperature fans should have valid European certification in accordance with EN 12101-3.

BRIEF SEQUENCE OF OPERATION:

The Ductless system shall consist of jet fans, CO sensors, and control panel for each basement.

The control panel shall provide power to Jet fans & CO sensors and shall switch on & off the jet fans based on demand.

CO sensors shall be placed at different locations in each basement and also the Jet fans will be located at strategic locations as suggested by the supplier.

Set of jet fans shall run based on Start/stop command from control panel.

The CO level will be sensed by the CO sensors and the signal will be relayed to control panel.

Control panel shall decide to run set of jet fans based on signal provided by CO sensors.

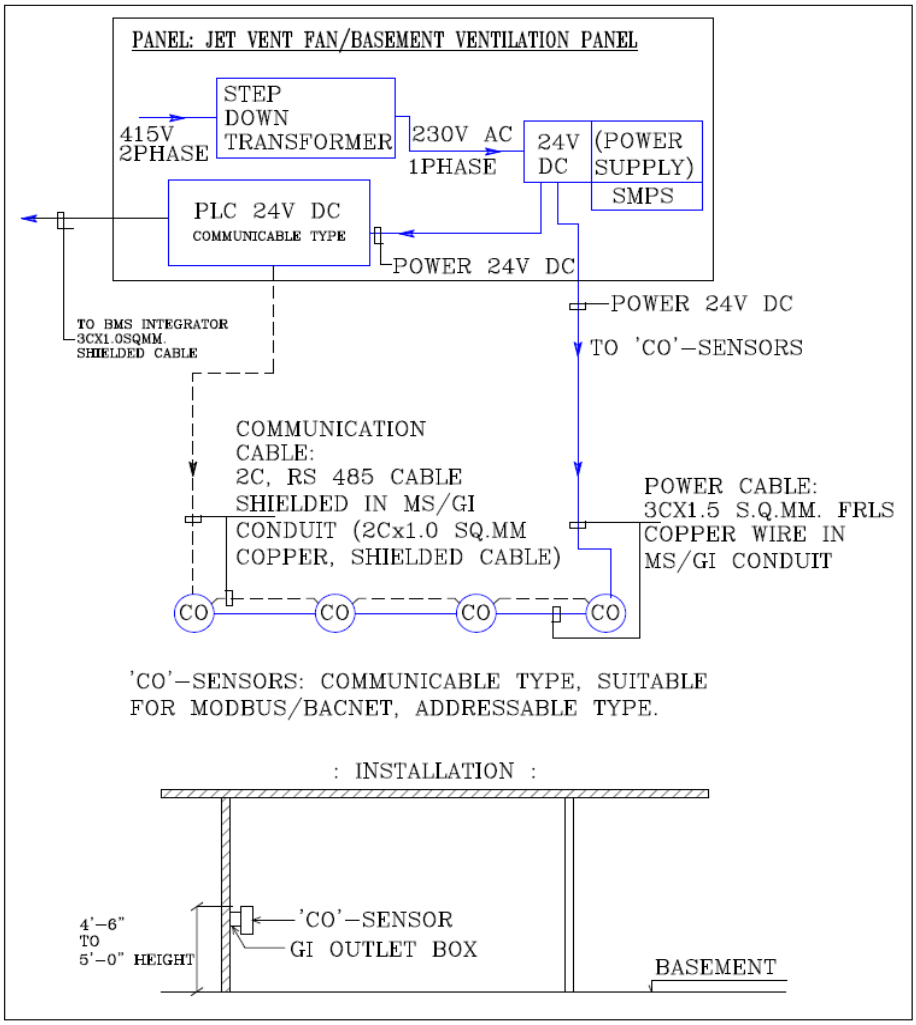
In case of fire, Control panel shall start all the jet fans on the basis of Fire signal provided to the panel.

SUBMITTALS:
Submittals shall include the following:

1. Sequence of operation
2. Jet Fan drawing indicating dimensions
3. Power and control wiring diagrams whichever is applicable
4. Fan data sheets

QUALITY ASSURANCE:
The Supplier of Ductless ventilation system shall assume "Unit Responsibility" for the complete ductless ventilation package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the supplier.

Bidders shall comply with all sections of this specification relating to packaged systems. Any deviations from this specification shall be bid as a voluntary alternate clearly defined in writing. If no exceptions are noted, the supplier or contractor shall be bound by these specifications.



SMPS & CONTROL TRANSFORMER FOR 'CO' SENSORS POWER & PLC:

Step 1 (Control Transformer) : 415V (2 Phase) to 230V (1 Phase)

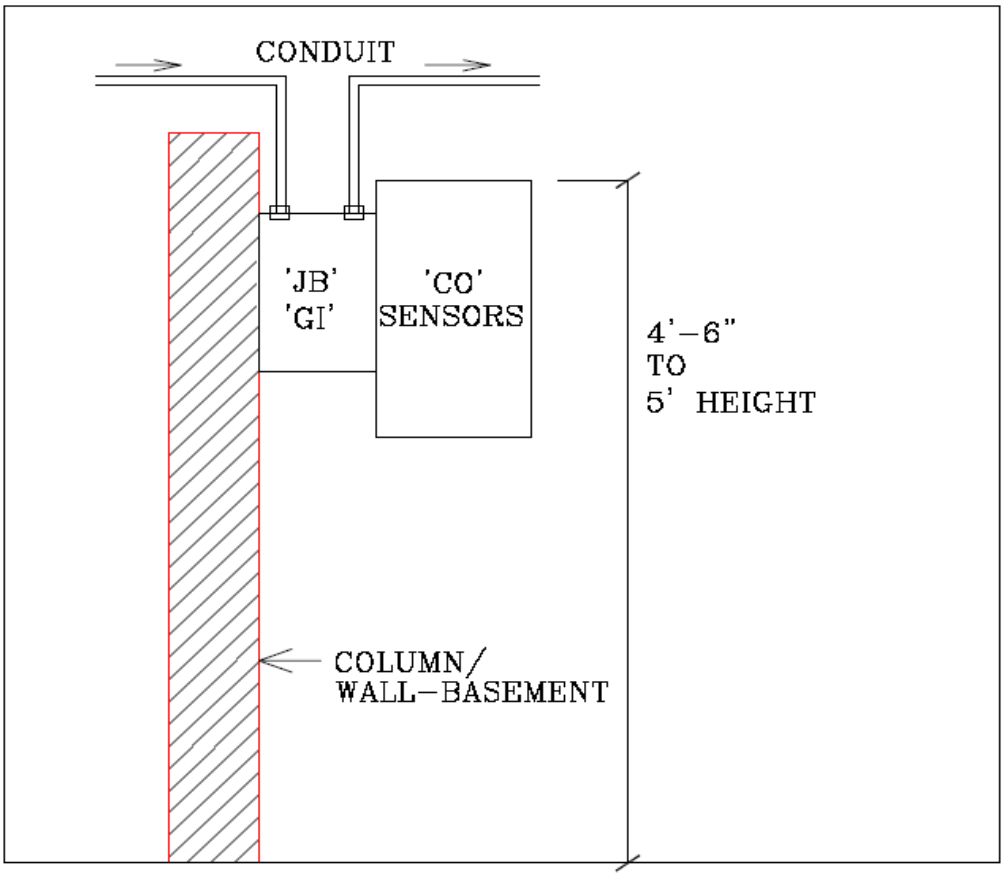
Step 2 (SMPS) : 230V (1 Phase) to 24V DC

24V DC Supply to:

- 'Co' Sensors
- 'PLC'

PLC'S FOR JET FANS & BASEMENT VENTILATION FANS:

- Power Input: 24V DC
- Relay Outputs: 24 Nos.
- Analogue Outputs: 20 Nos.
- Modbus Input Ports (RS485) : 4 Nos.
- BMS Communication Port



: BOQ :

'CO' SENSORS WITH GI OUTLET BOX

- GI/MS CONDUIT -20MM DIA -SEPARATE FOR POWER & COMMUNICATION.
- 3x1.5 SQ.MM FRLS COPPER WIRE IN CONDUIT.
- 2C, RS 485 SHIELDED COMMUNICATION CABLE IN CONDUIT.

14. CO/CO_2 GAS DETECTOR / SENSOR

- 'CO' sensor shall be designed to detect Carbon Monoxide gas in the air.
- The sensor should have high accuracy even at low concentration.
- It should be suitable for installation in a parking lot, underground basements, tunnels & underground spaces.
- The model shall be compact in size and shall offer ease of installation.
- The device should be a solid state semi-conductor type sensor, high sensitivity and selectivity to carbon monoxide and low sensitivity to alcohol vapor.
- Sensor should meet the minimum technical parameters as listed below for CO sensor(Communicable: MODBUS)

a.	Detect range	:	0-500 ppm
b.	Accuracy	:	± 5PPM or 5% of reading (which ever is greater)
B1.	Communication:	:	MODBUS
c.	Output Signal	:	2-10V dc & 4-20mA (Selectable by jumper)
d.	Power supply	:	24V dc ± 20%
e.	Coverage area	:	Minimum 700 sq.m
f.	Protection class	:	IP 65
g.	Operating temperature	:	0-50°C
h.	Operating humidity	:	10% - 95%
i.	Housing	:	Fire proof ABS enclosure
j.	Response time	:	Less than 35 seconds
k.	Sampling time	:	1s

A. CO SENSORS - COMMUNICATION TYPE (MODBUS COMMUNICATION TYPE)

- Sensors can be looped in looped out in a daisy chain. Max.25 sensors in a loop.
- Addressable type, communicable type, Modbus / Backnet.
- Upto 25 sensors on one communication loop for signal communication.
- Sensors of different zones can be looped on same loop as each sensor is addressable.
- This results on saving in conduiting & wiring.
- 0-500 ppm range.
- Sensors can have PPM display also.
- PLC to be suitable for Modbus / Backnet communication.
- PLC to support about 25 sensors per communication loop.
- PLC to have a communication part for connectivity to BMS.

NOTES FOR COMMUNICATION TYPE SENSORS(MODBUS COMMUNICATION)

- Preferred coverage area : 700 sq.m per CO Sensor
- Mounting height of CO sensors on columns / walls : 4'-6" to 5'.
- Surface mounted.
- Install a G.I. box behind sensor for conduit in/out.
- For 3000 sqmt. Zone, about 5 CO sensors.
- Power cable : 24V DC (3 x 1.5 sqmm. FRLS Copper wire in G.I./MS conduit)
- Communication cable : 2C, RS 485 shielded communication cable in a separate G.I. / MS conduit. (2C x 1.0 sq.mm Shielded Copper Conductor cable)

CO SENSORS

B. ANALOGUE TYPE

- Each sensor to be wired separately from 'PLC' for communication of signal.
- Cable quantity is much more in Analogue type sensors.
- 0-250 ppm range

C. COMMUNICATION TYPE (MODBUS COMMUNICATION)

- Sensors can be looped in looped out.
- Addressable type, communicable type, Modbus / Backnet.
- Upto 25 sensors on one communication loop for signal communication.
- Sensors of different zones can be looped on same loop as each sensor is addressable.
- This results on saving in conduiting & wiring.
- 0-500 ppm range.
- Sensors will have PPM display also.
- PLC to be suitable for Modbus / Backnet communication.
- PLC to support about 25 sensors per communication loop.
- PLC to have a communication part for connectivity to BMS.

NOTES FOR COMMUNICATION TYPE CO SENSORS.

- Preferred coverage area : 700 sq.m per CO Sensor
- Mounting height of CO sensors on columns / walls : 4'-6" to 5'.
- Surface mounted.
- Install a G.I. box behind sensor for conduit in/out.
- For 3000 sqmt. Zone, about '7' CO sensors.
- Power cable : 24V DC (3 x 1.5 sqmm. FRLS Copper wire in G.I./MS conduit)
- Communication cable : 2C, RS 485 shielded communication cable in a separate G.I. / MS conduit. (2C x 1 sq mm Shielded copper conductor cable).

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SUBHEAD-F. ELECTRICALLY OPERATED HOT WATER GENERATOR

1. SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at supplier's works, delivery at site, handling at site, installation, testing, commissioning and carrying out performance test at site of Electrical Hot Water Generator.

- **Temperature Control** Shall be through SCR.
- **Low Water Cut off** switch to be included to de-energize the HWG if the water level drops.
- **Pressure Relief Valve** duly factory calibrated is to be provided to relieve excess pressure.
- **Air Purge Valve** to bleed of the air automatically found in the water line to be provided.
- **Temperature & Pressure Gauges** are to be provided at inlet and outlet
- **Flow switch** to be installed in water return line to de-energize the unit if water flow stops

BMS Compatible

- Dry contacts for start/stop command, on/off status indication, fault indications such as high temperature and low water level.
- Provision for remote operation and local remote selector switch status.
- RS-485 communication port for remote programming and control.

BMS Compatible : It shall be BMS Compatible.

Isolated RS-232 C/RS-485 port, RJ45 Ethernet port for communication.
It should have protocol compatibility : DH-485/Modbus/ Profibus / BACnet

Additional Features the hot water boiler shall have:

- Fully BMS and SCADA Compatibles for remote programming and operation.
- Embedded LCD (HMI) Supports SD memory cards & Several language options for display
- Remote programming and control gives user the option to better monitor operate and sync the data with any other system.
- Operating parameters like inlet and outlet temp., pressures & flow shall be available at remote.
- Data acquisition for Trip history, Operational parameters & Run Hour.
- Automatic stage sequence reversal after user defined operation hours to equalize the operation time of each heater bank.

Control & Safeties:

- **Suitable rating Incomer MCCB** with electrolytic grade copper bus bars and mechanical interlock for safe operation to be used.
- **Magnetic contractors** of suitable rating with MCB for heater switching to be used.
- **LED Pilot Lights** shall indicate the functional operation. The most commonly specified functions are Phase indications, Each stage of heater power ON, Supply ON.
- **Alarm package** shall de-energizes the boiler and shall give audible and visual indications of high temperature low water level or zero flow rates. Each condition to be indicated with a separate pilot light.
- **Temperature Control** using Microprocessor based multistage electronic progressive staging sequencer with thermistor sensor to control the HWG in stage. Logic and control circuits continuously monitor the input signal to determine if more or less heat is required. Appropriate action is then taken automatically.
  a. Step controllers (Sequencer) are fail safe.
  b. Reset to OFF if the power is interrupted.
  c. Cycles down if Sensor leads are cut or short circuited.
  d. The Temperature Span and Time Delay (1-75 Sec.)

- **Top openable MS plate** shall be designed for maximum element to water contact for efficient operation.
- **Insulation** of 100 mm thick resin bounded fiberglass wool of density 32 kg/m3 and cladded with aluminum sheet to minimize heat loss shall be used.
- **Connections for water inlet & outlet** shall be provided with mating flanges. All vessels should have point & drain connection for system drainage.

- Control Cabinet shall be made out of CRCA steel sheet 16 gauge minimum, powder coated with high grade paint and provided with louvers to ensure adequate ventilation of the control and heater terminal compartment. Access to all control components shall be through hinged doors with lockable pad lock

- **Base frame** shall be fabricated out of ISMC100 channel.
  Electrical Hot Water Boilers shall have the following features:
  Standard Features:

- **Type & orientation** of Hot Water generator shall in vertical or horizontal configuration shall have degree of protection IP:52 for indoor & IP:55 for outdoor.

- **Flanged type immersion Heaters**: Consisting of multiple tubular heating elements formed into hairpins that are brazed to a pressure rated flange. A flange gasket of a suitable material shall be used for the pressure, temperature and material being heated.

- **Heating elements** shall consist of helical coil of 80% Nickel 20% Chromium alloy resistance wire shall be fusion welded to the nickel-coated steel terminal cold pin. The tubular element sheath materials shall be Copper, Incoloy @ 304.

- **Water vessel** shall be designed in accordance with ASME Boiler & pressure vessel code, for a maximum of 160 psig working pressure 250 Degree F.

Technical Parameters of Electrical HOT Water Boiler (the dimensions and connection sizes as mentioned in the table are just for reference. Actual sizes shall vary from supplier to supplier. Shop drawings preparation should take into account the space constraints / space availability for the hot water boiler and accordingly it's dimensions and connections sizes need to be finalized in the shop drawings / TDS approval stage)

RATING		SWITCH RATING		APPROX. DIMENSIONS			APPROX CONN. SIZE (mm
KW	kCal/HR	AMP	I/C	W	H	D	
12	11000	17	32A	550	1100	750	50
18	16000	25	32A	550	1100	800	50
24	21000	33	63A	600	1000	800	50
30	26000	42	63A	650	1150	750	50
36	31000	50	63A	650	1150	750	50
45	39000	63	100A	650	1150	850	50
51	44000	71	100A	600	1200	850	50
63	55000	88	125A	600	1335	850	50
75	65000	104	125A	650	1335	850	50
81	70000	113	125A	650	1335	850	50
90	78000	125	150A	650	1335	850	75
100	87000	139	200A	650	1335	850	75
120	104000	167	200A	750	1535	950	75
125	108000	174	250A	750	1535	950	75
150	130000	209	250A	750	1535	950	75
180	155000	250	315A	750	1535	950	75
200	173000	278	400A	750	1535	950	75
225	194000	313	400A	750	1535	950	75
250	216000	348	400A	750	1535	950	75
270	233000	376	500A	900	1635	1200	100
300	259000	417	630A	900	1635	1200	100
350	302000	487	630A	900	1635	1200	100
360	310000	501	630A	900	1635	1200	100
400	345000	556	800A	1000	1635	1200	100

450	388000	626	800A	1100	1750	1400	100
500	431000	696	800A	1100	1750	1400	150
525	452000	730	1000A	1100	1750	1400	150
550	474000	765	1000A	1100	1750	1400	150
600	517000	835	1200A	1200	1850	1500	150
720	620000	1002	1600A	1200	1850	1500	150
850	732000	1183	1600A	1200	1850	1500	150

Vernier / SCR Control

Temperature control shall be achieved by vernier control. One vernier heater stage shall be connected to a slave SCR controller. Additional stage shall be sequenced ON & OFF while the SCR vernier stage automatically fills the gap between the step controlled stages, providing full proportional control over the entire heater KW range. Both the SCR vernier stage and the step controller stages are controlled by the step controller. This shall help in 0% - 100% of the total KW & very precise Temperature Control.

Microprocessor based controller

Hot water generator shall be complete with its microprocessor based controller & shall be able for software integration with BMS.

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SUBHEAD-G. FAN COIL UNITS

1. SCOPE OF WORK

The specification for Fan Coil Units covers the design requirement, constructional feature, supply, installation, testing & commissioning.

2. THE HORIZONTAL TYPE OF FAN COIL

The horizontal type of fan coil units shall be complete with forward curved centrifugal blowers direct driven of aluminum construction, fan motor, cooling coil, heating coil and sandwiched type insulated drain pan extended type to accommodate all the valves as required for chilled water pipe connection. Centrifugal blowers shall be statically & dynamically balanced & shall be 2 or more light weight impellers.

All ceiling suspended fan coil units shall be securely mounted from the building structure.

Single Skin Design:

FCU shall be of single skin design, if called for in the schedule of quantities (BOQ).

It shall be single skin cabinet of 20G pre-coated GI sheets.

FCU shall be constructed out of 20 G Pre-Coated GI sheet and complete with Sandwitched Main & Auxiliary drip tray. Each drip tray shall be with top sheet of SS 306 & bottom sheet as 20 G Pre-coated GI sheet with sandwitch thermal insulation of Nitrile Rubber of 12mm thickness.

The main pan shall be long enough to cover cooling coil, supply & return headers, bends, valves, strainers and copper piping.

The auxiliary drain pan shall cover the valve set. The auxiliary drain pan shall be of sufficient size to collect drippage / condensation from the valve set.

FCU Thermostat:

- FCU thermostat shall be with its controller i.e. thermostat cum controller.
- FCU thermostat shall be able to perform the following operations:
  - Fan ON / OFF & speed control i.e. low medium & high based on room temperature & set point.
  - Control PICV valves ON / OFF or modulation based on PICV valve & suitable for 2 pipe / 4 pipe system (heat / cool option).
  - Communicate with BMS for remote monitoring & control / or communicate with room controller (in case of guest rooms management system).
  - Achieving occupied / unoccupied mode through occupancy sensor or receiving signal from door control.

Factory Fitted Valve Set:

FCU shall be complete with factory fitted valve set as described below in the option of Additional items. And a 230V / 24V DC power supply in a earthed box / enclosure for power to PICV valve & thermostat and interconnecting wiring.

Double Skin Design:

FCU of double skin design to be considered if asked for in the schedule of quantities (BOQ).

Double skin cabinet having 15mm PUF injected panel (40 kg / Cum density) made of 0.6mm GI pre-coated sheet as outer skin & 0.6mm plain GI sheet as inner skin.

Sandwitched Main & Auxiliary drip tray. Each drip tray shall be with top sheet of SS 306 & bottom sheet as 20 G Pre-coated GI sheet with sandwitch thermal insulation of Nitrile Rubber of 12mm thickness.

Main drain pan and auxiliary drain pan shall be of same specifications as mentioned in single skin design

of FCU.

FCU Thermostat:

- FCU thermostat shall be with its controller i.e. thermostat cum controller.
- FCU thermostat shall be able to perform the following operations:
  - Fan ON / OFF & speed control i.e. low medium & high based on room temperature & set point.
  - Control PICV valves ON / OFF or modulation based on PICV valve & suitable for 2 pipe / 4 pipe system (heat / cool option).
  - Communicate with BMS for remote monitoring & control / or communicate with room controller (in case of guest rooms management system).
  - Achieving occupied / unoccupied mode through occupancy sensor or receiving signal from door control.

Factory Fitted Valve Set:
FCU shall be complete with factory fitted valve set as described below in the option of Additional items. And a 230V / 24V DC power supply in a earthed box / enclosure for power to PICV valve & thermostat and interconnecting wiring.

3. COIL

The cooling coil shall be 3 row cooling / 4 row cooling / (3 row cooling + 1 row heating) copper tube coil with aluminum fins as called for in BOQ, having minimum 12 FPI. The fins configuration of Sigma flow or plain fin shall be acceptable. The OD of copper tube shall be minimum 9.5 mm & wall thickness of 0.35 mm. Hot water coil wherever provided shall be 1 row deep.

Water side coil working pressure shall be as specified in the schedule of quantities (BOQ):

i. PN10 / 10 Kg per cm² / 10 Bar
OR
ii. PN16 / 16 Kg per cm² / 16 Bar

And test pressure shall not be less than 1.5 times the working pressure.

All coils shall be factory tested @ 21 kg/cm2 (300 psi) air pressure while submerged in water.
Tubes shall be mechanically / hydraulically expanded for minimum thermal contact resistance with fins. Air vent shall be provided in header at a level higher than coils.

4. MOTOR

Motor shall be AC or DC (BLDC) EC Motor as called for in the BOQ:

AC Motor:- Motor shall be 220 + 10% volts, 50 cycles, single phase, six pole/ four pole, permanent split capacitor shaded pole type, speed not exceeding 1250 RPM at maximum airflow. Motors shall have three speed windings and shall be factory wired to a terminal block mounted within the fan section. Motors shall be have extended shaft on both sides. Low, medium & high speed motor i.e. motor shall be 3 steps.

OR

DC Motor:- Motor shall be inverter-based Brushless Direct Current type (BLDC) EC motor has high torque, high PFC value, longer life cycle, and reduced noise pollution levels. , while generating up to 140% more instant air volume and shall be factory wired to a terminal block mounted within the fan section. Motors shall be have extended shaft on both sides. The Units employ the PI control mechanism for temperature control. Motor shall be step less type.

The FCU shall have lowest operating noise level for sound and performance. The Fan Coil Units shall be provided with the following accessories:

a. Double fire retardant Canvass Connection.
b. Synthetic Nylon filter, washable type of MERV 4 efficiency.
c. Copper connections between chilled water lines, controls etc.
d. Electrical wiring between motors & speed regulator / thermostat along with a suitable matching

thermostat.

e. Strainer with ball valve at inlet & ball valve at outlet.
f. 2 Way PID balancing cum control valve or 2 Way On/Off valve with automatic balancing valve.

Note: accessories "e" & "f" as mentioned above are to be considered as part of the FCU or separately as the case may be , as mentioned in the schedule of quantities of FCU's. In other words, FCU's may be required with Pre fit Valve assembly i.e. with items "e" & "f" factory fitted in FCU, as mentioned above , if its specified so in the schedule of quantities.

Each Fan Coil Unit shall be tested at factory & complete in all respects. The sound level of the unit should not exceed the sound level as specified in the schedule of quantities for each rating/capacity of FCU. The test certificate shall be furnished with each Coil Unit. It is necessary to design the fan coil unit in a way to have silent operation.

5. FLOOR MOUNTED/WALL MOUNTED FAN COIL UNIT

Finished floor mounted/wall mounted units shall be in cabinets constructed of 18 gauge die-formed, cold rolled, galvanized sheet steel and painted with approved shade of powder coating finish. The cabinet shall be of sufficient size to enclose all pipes and control valves.

6. TECHNICAL REQUIREMENTS OF FAN COIL UNITS

The Parameters of Fan Coil Units are given below:

FAN COIL UNIT:

Capacity	**1.5TR**	**2.0TR**	**2.5TR**	**3.0TR**
a) Air quantity CFM	600	800	1000	1200
b) Fan Static pressure (ESP)	----------As per Schedule of quantities ----------			
c) Face area of Coil	------to suit the requirement at 500 FPM-----			
d) Minimum no. of fins/inch	----------12----------			
e) No. of rows deep	3	3	3	3
(As per schedule of quantities)	4	4	4	4
f) Motor HP	--------(Fractional HP, Single phase)----------			
g) Sandwiched tray	----------YES----------			
h) Type of painting	----------Powder coated finish only----------			

7. PERFORMANCE TESTING

Prior to transportation, FCU shall be subjected to inspection and witness of performance testsby Department or his authorized representative/ Consultant / Architect to verify various performance parameters as confirmed by contractor earlier at the time of award of contract. The contractor shall quote separately including the charges for all stage wise inspection(s) and performance testing(s). The charges shall also include travel, boarding & lodging of a maximum of three persons of Department or his representative / Consultant /Architect for each of the inspection(s) and performance testing(s).

One FCU of each type shall be factory Performance tested in the presence of Department or his representative / Consultant / Architect. The manufacturer shall supply certified test reports to confirm performance as specified.

The equipment will be accepted if the test procedures and result are in conformance with data submitted earlier at the time of award of contract. If the equipment fails to perform within the allowable tolerances, the manufacturer will be allowed to make one revision to its equipment and retest as required. The contractor shall pay all associated expenses resulting from retesting. In the event that this revision does not achieve submitted performance, Employer reserves the right to reject the equipment or accept with a penalty.

8. INSTALLATION

Ceiling suspended horizontal units and units mounted within the ceiling space shall be hung through

rubber in shear vibration isolator suspenders to be provided alongwith the FCU and to be included in the cost.

SUBHEAD-H. INSULATION

I. INSULATION WITH RESIN BONDED FIBRE GLASS WOOL:

a. ACCOUSTIC LINING OF DUCTS:

Ducts internal acoustic lining can be carried out by the following material and method:

Resin Bonded Fibre Glass Wool

Insulation material for Duct Acoustic Lining shall be resin bonded fiberglass wool board with one side factory laminated Black glass cloth & the other side shall be Aluminium foil. The Thermal conductivity of the fiberglass for air-conditioning application shall not exceed 0.034 W/m K at 25 deg C mean temperature. The density of insulation material shall be 48 Kg./m3 and thickness of insulation material shall not be less than 12mm.

The installation guideline for glasswool in Duct Acoustic Lining :

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

Fiberglass wool board should be placed in such a way that black glass cloth is visible from inside the duct and it is pasted/screwed on GI duct with suitable adhesive/screw bolt

Note: AHU Plenum and First three running meters of supply air ducts need to be acoustically lined.

b. ACCOUSTIC LINING OF WALLS/CEILING OF AHU ROOMS & DG SET ROOM

Rooms acoustic lining can be carried out by the following material and method:

Resin Bonded Fibre Glass Wool
Acoustic Insulation Product
Acoustic Board: Glass Wool insulation board
Density: 70 to 80 Kg/m3
Thickness: 25 mm
Lamination: One Side Aluminum foil & other side Black Glass Cloth
Size: 3M x 1.2 M or 1.2M x 0.6M

Parameter	**Technical Specification (Acoustic Board)**
Material	Resin bonded fiberglass wool
Standard/Codes to follow	IS 8183: 93 /IS 3144: 90
Physical form	Standard Board Size : 3 M x 1.2 M or 1.2M x 0.6M
Nominal bulk density	70-80 Kg/m^3
Thickness	25 mm
R-value in sq.m. K/W (at 25mm thickness)	R-0.65
Facings	Factory lamination with one side FSK (Aluminum foil) & other side Black Glass Cloth
Thermal conductivity	0.038 W/MK deg C
Parameter	**Glass Wool Conformance**
Fire Properties	
Non combustibility	Non combustible as per BS 476 part 4
Ignitibility	Class P (Not easily ignitable material) as per BS 476 part 5
Surface Spread of flame	NIL. Class 1 as per BS 476 part 7
Fire propagation	Class 'O', [index I<12, sub-index i1<6].Conforms to BS 476 part 6 and 7.
Toxicity	Non toxic as per BS 6853
Moisture content	<2% .conforms to IS 3144/IS 8183
Shot content	Nil.(<2%). conforms to IS 3144/IS8183
Sulphar /Chloride content	Nil. Conforms to IS 3144/IS 8183

Mould growth	Conforms to IS 3144/IS 8183. Inorganic glass fiber does not support mould growth.
NRC (Noise Reduction Coefficient)	0.65 (NRC is calculated as per ASTM C-423)
Chemical	Neither acidic no basic, chemically almost neutral. PH value very close to 7.

Installation guidelines:

1 The surface of the wall and roof should be cleaned properly and Acoustic board has to fit directly on the wall of the room and roof with the help of screw (2 inch) and GI washers (3 inch x 3 inch).

2 The Acoustic board should be placed in such a way that black glass cloth is visible from inside the AHU / DG Set room. Complete as required and as per specifications.

c. DUCT THERMAL INSULATION (Indoor)

Resin Bonded Fibre Glass

Insulation material shall be non-toxic , chemically inert , non-combustible, non-ignitable, shall have zero ozone depletion potential, zero calorific value no heat evolution and shall be inherently proof against rotting , mould and fungal growth and attack by vermin.

The materials shall comply with following standards.

BS 476: Part 4 – Non Combustible

BS 476: Part 5 – Not easily Ignitable (Class P)

BS 476: Part 6 – Fire propagation Index (I<12)

BS 476: Part 7 - Surface spread of flame (Class 1)

The material should comply Class'O' fire rating as per (BS 476 part 6&7).

The material should comply non-combustibility (BS 476 Part 4) as per National Building Code-2016 (NBC-2016 mandates that for duct insulation non-combustible material should be used).

The product shall be able to work effectively at ambient temperature range of -195ºC to 230 ºC.

Material: Insulation material of Duct shall be with resin bonded fiberglass wool, one side factory laminated with WMPVR R Plus (tough guard) and other side with black glass tissue. The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature.

The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.

The minimum thermal resistance (R-Values) for insulation of ducts (as per ASHRAE 90.1-2004 and ECBC 2017) shall be as described below:

R= 1.4 m^2 deg. /W-Supply Duct (Unconditioned Space) (Thickness requirement for glasswool 50MM)
R= 0.6 m^2 deg. /W-Supply Duct (Conditioned) (Thickness requirement for glasswool 25MM)
R= 0.6 m^2 deg. /W-Return Duct (Conditioned & Unconditioned) (Thickness requirement for glasswool 25MM)

Thickness of insulation for supply and Return duct as per duct location:

Duct Location - Indoor	Supply Duct	Return Duct
Duct in Conditioned Space, when surrounded by cool return air, when return air is not ducted.	25 mm	
Duct in Unconditioned Space, when not surrounded by cool return air, when return air is also ducted.	50mm	25mm

The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m3.
The minimum thickness of material used for duct thermal insulation shall be 25mm.

The installation guideline for glasswool duct-wrap:

- Duct shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease.
- The Duct joint should be sealed against leakages
- The CPRX compound should be applied over duct surface and Fiberglass wool insulation shall be fixed tightly to the surface.
- All joints shall be sealed properly by means of 75 mm wide self-adhesive aluminum tape of approved make.

d. DUCT THERMAL INSULATION (Outdoor)

Insulation material shall be non-toxic , chemically inert , non-combustible, non-ignitable, shall have zero ozone depletion potential, zero calorific value no heat evolution and shall be inherently proof against rotting , mould and fungal growth and attack by vermin.

The materials shall comply with following standards.
BS 476: Part 4 – Non Combustible
BS 476: Part 5 – Not easily Ignitable (Class P)
BS 476: Part 6 – Fire propagation Index (I<12)
BS 476: Part 7 - Surface spread of flame (Class 1)

The material should comply Class'O' fire rating as per (BS 476 part 6&7).
The material should comply non-combustibility (BS 476 Part 4) as per National Building Code-2016 (NBC-2016 mandates that for duct insulation non-combustible material should be used)
The product shall be able to work effectively at ambient temperature range of -195ºC to 230 ºC

Material: Insulation material of Duct shall be with resin bonded fiberglass wool, one side factory laminated with Aluminium facing and other side with black glass tissue. The Thermal conductivity of the insulation material shall not exceed 0.034 W/m K at 25 deg C mean temperature.

All insulation shall be provided with the protective coating as per BS 476 Part-7, Class-'1', IS101(Part-2/Sec-2)/1986 and IS 101 (Part-2/Sec-1)/1988 foster/starbond 30-36/chemxcoat with three coat with the reinforcement as per IS 11871 glass fiber cloth . Each coat should be dry before another coat. The coverage of each coat not less than 1 kg. per 43.04 sq. ft. ($4m^2$/coat).

The thickness of insulation shall be so selected as to prevent any condensation and should be able to meet R-Value requirements.

The minimum thermal resistance (R-Values) for insulation of ducts (as per ASHRAE 90.1-2004 and ECBC 2017) shall be as described below:

R= 1.4 m^2 deg. /W-Supply Duct (Unconditioned Space) (Thickness requirement for glasswool 50MM)
R= 0.6 m^2 deg. /W-Supply Duct (Conditioned) (Thickness requirement for glasswool 25MM)
R= 0.6 m^2 deg. /W-Return Duct (Conditioned & Unconditioned) (Thickness requirement for glasswool 25MM)

Thickness of insulation for supply and Return duct as per duct location:

Duct Location – Outdoor, on terrace or in shaft	**Supply Duct**	**Return Duct**
Duct in Unconditioned Space	50mm + UV Protected Coating	25mm+ UV Protected Coating

The nominal density of Resin Bonded Fiberglass insulation shall be 32 kg/m3
The minimum thickness of material used for duct thermal insulation shall be 25mm.

The installation guideline for glass wool duct-wrap:

- Duct shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease.
- The Duct joint should be sealed against leakages

- The CPRX compound should be applied over duct surface and Fiberglass wool insulation shall be fixed tightly to the surface.
- All joints shall be sealed properly by means of 75 mm wide self-adhesive aluminum tape of approved make.
- Apply tack coat of foster/starbond 30-36/chemxcoat over the insulation and embed immediately non-combustible (Glass Fiber Cloth) 7 Mil only fabric for reinforcement. (UV treatment).

- Apply 1st coat of foster/starbond 30-36/chemxcoat evenly.
- Apply 2nd coat foster/starbond 30-36/chemxcoat after curing the 1st coat as per supplier recommendation.

e. PIPING INSULATION (Within the AC Plant Room) (Fibre Glass Insulation with Aluminium Cladding):

Chilled water, Hot water and drain piping shall be insulated with rigid Glass wool preformed pipe section. The insulation material shall be confirmed these specifications.

The Fiberglass wool insulating material shall be applied for Chilled Water pipes as under.
Rigid pre-formed moulded sections of fiberglass wool having a uniform density range 64-80 Kg/m^3.
and thermal conductivity shall not be more than 0.033 W/mK at 25º C mean temperature. The material for piping insulation shall be factory laminated on one side with Aluminum foil on the outside face, and fused to the insulation material, as specified. The Aluminum foil shall extend by a minimum 50 mm on one side of the pipe section along the length to seal all longitudinal joints. Bonding of insulation material shall be with a cold setting compound. Adhesive Mechduct (Mechmaark) used for setting the insulation shall be, vapour proof adhesive.

Pipe Dia (NB)	Thickness (MM)
20 -100	25
125-300	50
Above 300	75

METHOD OF INSULATION APPLICATION:

1. Pipes shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease and prime with chlorosulphonated zinc chromate/ phosphate coating confirm to IS 35476 PT 20 & 22.
2. The pipe should be inspected and all joints should be sealed against leakages.
3. Two coats of CPRX compound adhesive shall be applied on the cleaned and primed pipe surface.
4. Two coats of CPRX compound shall also be applied on the inner side of the Aluminium foil faced fiber glass wool rigid pipe sections.
5. Wrapping the insulation with two layers of 500 microns polythene sheet with PVC tape & further tying with fine aluminium wire.
6. Fiberglass wool rigid pipe sections than shall be fixed tightly to the surface. All joints to be sealed properly. All joints of Aluminum foil of the insulation shall be sealed properly by means of 75 mm wide self-adhesive aluminum tape of approved make.
7. Pipe Insulation shall be cladded with 26 gauge aluminium over the pipe insulation.

f. PIPING INSULATION (Outdoors on Terrace/In shafts/ in AHU rooms for AHU's / with in building above false ceiling) (Fibre Glass Insulation with 7 ml glass cloth & UV protective coating):

Chilled water, Hot Water and drain piping shall be insulated with rigid Glass wool preformed pipe section. The insulation material shall be confirmed these specifications.

The Fiberglass wool insulating material shall be applied for Chilled Water pipes as under.

Rigid pre-formed moulded sections of fiberglass wool having a uniform density range 64-80 Kg/m^3 and thermal conductivity shall not be more than 0.033 W/mK at 25º C mean temperature. The material for piping insulation shall be factory laminated on one side with Aluminum foil on the outside face , and fused to the insulation material, as specified. The Aluminum foil shall extend by a minimum 50 mm on one side of the pipe section along the length to seal all longitudinal joints. Bonding of insulation material shall be with a cold setting compound. Adhesive Mechduct (Mechmaark) used for setting the insulation shall be, vapour proof adhesive.

All insulation shall be provided with protective coating as per BS 476 Part-7, Class-'1', IS101(Part-2/Sec-2)/1986 and IS 101 (Part-2/Sec-1)/1988 ,UV proteced foster/starbond 30-36/chemxcoat /chemxcoat with three coat with the reinforcement as per IS 11871 glass fiber cloth . Each coat should be dry before another coat. The coverage of each coat not less than 1 kg. per 43.04 sq. ft. (4m²/coat).

The thickness of insulation material shall be selected with diameter of pipe as below:

Pipe Dia (NB)	Thickness (MM)
20 -100	25
125-300	50
Above 300	75

METHOD OF INSULATION APPLICATION:

1. Pipes shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease and prime with chlorosulphonated zinc chromate/ phosphate coating confirm to IS 35476 PT 20 & 22.
2. The pipe should be inspected and all joints should be sealed against leakages.
3. Two coats of CPRX compound adhesive shall be applied on the cleaned and primed pipe surface.
4. Two coats of CPRX compound shall also be applied on the inner side of the Aluminium foil faced fiber glass wool rigid pipe sections.
5. Fiberglass wool rigid pipe sections than shall be fixed tightly to the surface. All joints to be sealed properly. All joints of Aluminum foil of the insulation shall be sealed properly by means of 75 mm wide self-adhesive aluminum tape of approved make.
6. Apply tack coat of protective coating over the insulation and embed immediately non combustible (Glass Fiber Cloth) 7 Mil only fabric for reinforcement.
7. Apply 1st coat of protective coating evenly.
8. Apply 2nd coat protective coating after curing the 1st coat as per supplier recommendation.

g. PIPING INSULATION (Buried in Ground) (Fibre Glass Insulation)

Chilled water, Hot Water and drain piping shall be insulated with rigid Glass wool preformed pipe section. The insulation material shall be confirmed these specifications.

The Fiberglass wool insulating material shall be applied for Chilled Water pipes as under.

Rigid pre-formed moulded sections of fiberglass wool having a uniform density range 64-80 Kg/m^3 and thermal conductivity shall not be more than 0.033 W/mK at 25º C mean temperature. The material for piping insulation shall be factory laminated on one side with Aluminum foil on the outside face , and fused to the insulation material, as specified. The Aluminum foil shall extend by a minimum 50 mm on one side of the pipe section along the length to seal all longitudinal joints. Bonding of insulation material shall be with a cold setting compound. Adhesive Mechduct (Mechmaark) used for setting the insulation shall be, vapour proof adhesive.

The thickness of insulation material shall be selected with diameter of pipe as below:

Pipe Dia (NB)	Thickness (MM)
20 -100	25
125-300	50

Above 300	75

METHOD OF INSULATION APPLICATION:

1. Pipes shall be thoroughly cleaned with wire brush and rendered free from all foreign matter and grease and prime with chlorosulphonated zinc chromate/ phosphate coating confirm to IS 35476 PT 20 & 22.
2. The pipe should be inspected and all joints should be sealed against leakages.
3. Two coats of CPRX compound adhesive shall be applied on the cleaned and primed pipe surface.
4. Two coats of CPRX compound shall also be applied on the inner side of the Aluminium foil faced fiber glass wool rigid pipe sections.
5. Fiberglass wool rigid pipe sections than shall be fixed tightly to the surface. All joints to be sealed properly. All joints of Aluminum foil of the insulation shall be sealed properly by means of 75 mm wide self-adhesive aluminum tape of approved make.
6. Wrapping the insulation with two layers of 500 microns polythene sheet with PVC tape & secured with chicken wire mesh netting and finished with two layers each 6mm thick of sand cement plaster & final paint as approved.

h. ROOF / SLAB UNDERDECK INSULATION AS PER ECBC (Fibre Glass Insulation)

Insulation material for Metal/RCC Roof shall be done with 70-80 kg/m3 and **75 mm thick** Glasswool insulation board with one side Aluminium faced and other side black glass tissue. Thermal resistance of the Insulation should be R-2.5 sq.m.K/W and thermal conductivity value should not be more than 0.032 W/mK, and maximum thermal transmittance (U –Value) of the system should be 0.409 W/Sq.m K as per ECBC 2017 (Standard board sizes 3M x 1.2M or 1.2M x 0.6M).

R- Value is for the insulation alone and does not include building materials or air film, Whereas U- value include the building material or air films as per defined by ECBC 2017.

Insulation material shall be non-combustible (or incombustible) in compliance with IS 8183, BS 476 part 4 and ISO 1182 ,limited surface spread of flame in compliance to Class 1 as per BS 476 part 7, fire propagation indices I<12 and i<6 as per BS 476 part 6 to comply Class 0 criteria (BS 476 part 6 &7 together).

Method of installation:

1. The ceiling surface should be cleaned properly.
2. The board can be installed on ceiling with the help of Screw drill bits and washer. (2" screw & GI washers 3"x3")
3. The board should be installed such that its Aluminium facing should be visible and tissue faced side should be at ceiling side.

i. ROOF / SLAB UNDERDECK INSULATION NON-ECBC (Fibre Glass Insulation)

Insulation material for Metal/RCC Roof shall be done with 70-80 kg / m³ Glasswool insulation board with **50 mm thickness** with one side Aluminium faced and other side black glass tissue. Thermal resistance of the Insulation (50mm) should be R-1.6 sq.m.K/W and thermal conductivity value should not be more than 0.032 W/mK ,and Maximum thermal transmittance(U –Value) of the system should be 0.62 W/Sq.m K. Insulation material shall be noncombustible (or incombustible) in compliance with IS 8183, BS 476 part 4 and ISO 1182 ,limited surface spread of flame in compliance to Class 1 as per BS 476 part 7, fire propagation indices I<12 and i<6 as per BS 476 part 6 to comply Class 0 criteria (BS 476 part 6 &7 together) (Standard board sizes 3M x 1.2M or 1.2M x 0.6M).

Method of installation:

1. The ceiling surface should be cleaned properly.
2. The board can be installed on ceiling with help of Screw drill bits and washer. (2" screw & GI washers 3"x3")
3. The board should be installed such that its Aluminium facing should be visible and tissue faced side should be at ceiling side.

j MEASUREMENT OF INSULATION

1. Insulation of Chilled Water / Drain Water Pipes:

- Insulation of pipes shall be measured in terms of linear length of pipe for each size along the centre line of the installed pipe.
- For insulation of bends, elbows, tees etc. it shall be measured along with the center line of insulation and shall be measured in meters, and shall be measured as part of piping, and nothing extra to be charged for these.
- Insulation of valves shall be separately accounted as per bill of quantities.
- Insulation of expansion tank shall be accounted separately as per BOQ.

2. Acoustic Lining of Duct & Plenum:

This shall be measured on the basis of bare duct surface area i.e. the area of duct lining & area of duct shall be same.

3. Thermal Insulation of Ducts:

This shall be measured on the basis of bare duct surface area excluding all openings for grilles & diffusers and including all flanges & dampers etc.

4. Acoustic Insulation of AHU Room & DG Set Room & Under Deck Roof Insulation:

This shall be measure on the basis of finished surface area of the wall & roof.

II. INSULATION WITH NITRILE RUBBER:

a. ACCOUSTIC LINING OF DUCTS:

Ducts internal accoustic lining can be carried out by the following material and method:

Open Cell Nitrile Rubber Foam:

i. With 15mm thick open cell nitrile rubber foam having anti-microbial product protection, having 140-180 kg/m^3 density and shall conform to Class – 1 rating for surface spread of flame as per BS 476 Part 7 insulation material. Insulation material shall have Microban anti-microbial product protection. It should not allow the microbes to function, grow and reproduce. Resistance towards micro-biological growth on insulation surface should conform to following standards:

Mould Growth	-	UL 181
Fungi Resistance	-	ASTM G21/C1338
Bacterial Resistance	-	ASTM E 2180

ii. Clean the duct surface.

iii. Apply Rubber based solvent adhesive recommended by the manufacturer on the internal surface of the duct.

iv. Cut insulation foamed sheets into required sizes. Apply adhesive on the foam and stick it to the duct surface.
v. Minimum insulation thickness to be 15mm.

Note: AHU Plenum and First three running meters of supply air ducts need to be acoustically lined.

b. ACCOUSTIC LINING OF WALLS/CEILING OF AHU ROOMS & DG SET ROOM

Rooms acoustic lining can be carried out by the following material and method:

Open Cell Nitril Rubber Foam:

i. Open cell Nitrile Rubber foam having microban anti-microbial product protection, of 25mm thickness and of 140-180 kg / m³ density shall conform to Class -1,cut to required sizes with a layer of adhesive / as recommended by the manufacturer.

ii. Clean the surface with brush to remove all dirt and cement etc and surface should be made smooth if un even.

iii. A layer of adhesive as approved by the manufacturer be applied on wall and ceiling with the help of a brush and allow it to tack dry.

iv. All insulation sheet, wall and ceiling surfaces shall have all over adhesive coverage.

v. 2 GI strips of minimum 18G or cross bars of equivalent or higher strength per square meter or per piece with 5 fasteners with one fastener in the centre shall be put diagonaly ,immediately after sticking with the help of adhesive. The length of the fastener should be 50mm more than the recommended thickness.

c. DUCT THERMAL INSULATION (Indoor)

Closed Cell Elastomeric Nitril Rubber

Insulation material shall be closed cell Elastomeric Nitril Rubber , class O , density of material shall be 40 to 60 Kg/cub.m. Thermal conductivity of the material shall not exceed 0.035 W/mK at an average temperature of 0 deg C. Material shall be FM approved.

Duct surfaces shall be cleaned to remove grease, oil, dirt etc before insulation. A thin film of the adhesive shall be applied on the back of the material and on the metal duct's surface. When adhesive is tack dry, insulating material shall be placed in position and pressed firmly. All joints longitudinal and transverse shall be sealed as per manufacturers recommendation.

d. DUCT THERMAL INSULATION (Outdoor)

Closed Cell Elastomeric Nitril Rubber

Insulation material shall be closed cell Elastomeric Nitril Rubber with factory laminated 7ml. UV treated glass cloth, class O, density of material shall be 40 to 60 Kg/cub.m. Thermal conductivity of the material shall not exceed 0.035 W/m°K at an average temperature of 0°C. Water vapour permeability shall not exceed 0.017 Perm inch (2.248 x 10-14 kg / ms.PA), i.e. Moistrure Diffusion Resistance Factor or 'μ' value should be minimum 7000. 'Material shall be FM approved.

Duct surfaces shall be cleaned to remove grease, oil, dirt etc. before insulation. A thin film of the rubber based solvent adhesive as recommended by the manufacturer shall be applied on the back of the material and on the metal duct's surface. When adhesive is tack dry, insulating material shall be placed in position and pressed firmly. All joints longitudinal and transverse shall be sealed as per manufacturers recommendation.

e. PIPING INSULATION (Indoors as well as Outdoors on Terrace/In shafts/ in AHU rooms for AHU's / inside the building above false ceiling spaces):

Closed Cell Elastomeric Nitrile Rubber:
Insulation material shall be closed cell Elastomeric Nitril Rubber, class O , density of material shall be 40 to 60 Kg/cub.m. Thermal conductivity of the material shall not exceed 0.035 W/m°K at an average temperature of 0°C. Water vapour permeability shall not exceed 0.017 Perm inch (2.248 x 10-14 kg / ms.PA), i.e. Moistrure Diffusion Resistance Factor or 'μ' value should be minimum 7000. 'Material shall be FM approved.

With Closed Cell Elastomeric Nitrile Rubber - (For Non - Costal Areas)
Insulation with Nitrile Rubber pipe sleeve or cut from sheets of Nitrile rubber insulation of thicknesses as specified, with manufacturer approved rubber based pipe seal adhesive, after cleaning the pipe surface, sealing of all joints. The pipe sleeves & cuts sheets shall be with factory laminated UV glass cloth & mechanical protection.

With Closed Cell Elastomeric Nitrile Rubber - (For Costal Areas)
Insulation with Nitrile Rubber or cut from sheets of Nitrile rubber insulation of thicknesses as specified, with manufacturer approved rubber based pipe seal adhesive, after cleaning the pipe surface, sealing of all joints. The pipe sleeves & cuts sheets shall be with factory laminated UV glass cloth & mechanical protection.

All chilled water, refrigerant and condensate drain pipe shall be insulated in the manner specified herein. An air gap of 25 mm shall be present between adjacent insulation surfaces carrying chilled water or refrigerant. Before applying insulation, all pipes shall be brushed and cleaned. All Pipe surfaces shall be free from dirt, dust, mortar, grease, oil, etc. Nitrile Rubber insulation shall be applied as follows:

Insulating material in tube form shall be sleeved on the pipes.

On existing piping, slit opened tube of the insulating material (slit with a very sharp knife in a straight line) shall be placed over the pipe and adhesive shall be applied as suggested by the manufacturer.

Adhesive must be allowed to tack dry and then press surface firmly together starting from butt ends and working towards centre.

Wherever flat sheets shall be used it shall be cut out in correct dimension. All longitudinal and transverse joints shall be sealed as per manufacturer recommendations.

The insulation shall be continuous over the entire run of piping, fittings and valves.
All valves, fittings, joints, strainers, etc. in chilled water piping shall be insulated to the same thickness as specified for the main run of piping and application shall be same as above. Valves bonnet, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

Or with special UV resistant paint on the insulation & then spreading 7 mil. woven glass cloth on the insulation when the paint is wet & then apply another coat of paint, when insulation is not factory laminated with UV lamination.

f. ROOF / SLAB UNDERDECK INSULATION NON-ECBC (With Nitrile Rubber)
Under deck thermal insulation of exposed roof as per the approved shop drawings/specifications. 25mm thick, 40-60 Kg /m³ density, closed cell elastomeric nitrile rubber class "O" secured with approved adhesive.

g. MEASUREMENT OF INSULATION

1. Insulation of Chilled Water / Drain Water Pipes:

- Insulation of pipes shall be measured in terms of linear length of pipe for each size along the centre line of the installed pipe.

- For insulation of bends, elbows, tees etc. it shall be measured along with the center line of insulation and shall be measured in meters, and shall be measured as part of piping, and nothing extra to be charged for these.
- Insulation of valves shall be separately accounted as per bill of quantities.
- Insulation of expansion tank shall be accounted separately as per BOQ.

2. Acoustic Lining of Duct & Plenum:
This shall be measured on the basis of bare duct surface area i.e. the area of duct lining & area of duct shall be same.

3. Thermal Insulation of Ducts:
This shall be measured on the basis of bare duct surface area excluding all openings for grilles & diffusers and including all flanges & dampers etc.

4. Acoustic Insulation of AHU Room & DG Set Room & Under Deck Roof Insulation:
This shall be measure on the basis of finished surface area of the wall & roof.

III. THERMAL INSULATION WITH PUF & TF QUALITY EXPENDED POLYSTYRENE / EXTRUDED POLYSTRENE

a. ROOF / SLAB UNDERDECK INSULATION: WITH Extruded Polystyrene
Under deck thermal insulation of exposed roof with 40mm thick, 32-35 Kg / m³ density Extruded Polystyrene (XPS) foam insulation boards (Ownes Corning - Foamular-Meteric 150) secured with approved adhesive and further secured with dash fastners at regular interval as may be required.

b. DUCT THERMAL INSULATION (Outdoor) – with TF Quality Expanded Polystryrene
50mm thick TF Quality Expanded Polystyrene as specified in the BOQ, 32 Kg / M³ density, secured with CPRX compound and wrapping the insulation with 2 layers of 500 micron polythene sheets and secured with chicken wire mesh netting and finished with 12mm thick sand cement plaster and painting as required.

c. Piping Insulation with TF Quality Expanded Polyestrene finished with Sand Cement Plaster Or Aluminium Cladding : Indoor/Outdoor/In ground

50mm / 75mm thick Insulation with pipe sections or cut from slabs of Expanded Polyestrene for bigger size pipes, of density 32 kg / m³ & thickness as specified below with CPRX adhesive after cleaning the pipe surface, wrapping the insulation with 2 layers of 500 micron polythene sheet with PVC tape, secured with chicken wire mesh netting & finished with 12mm thick sand cement plaster & final painting **(In shafts / on terrace / outdoors / burried in ground in trenches).**

Expanded polystyrene insulation for **indoor application** can also be finished with 2 layers of 500 micron polythene sheet barrier with PVC tape & additionally tying with fine aluminium wire and applying 26G aluminium sheet cladding.

d. PIPING INSULATION (Within the AC Plant Room) – with PUF insulation:
30 / 40 / 50 / 65 mm thick PUF insulation etc., 36 kg / M³ density with Aluminium foil with 50 mm overlap on joints and fixed with self adhesive aluminium tape & wrapping the insulation with 2 layers of 500 micron polythene sheet with PVC tape & additionally tying with fine aluminium wire and covered with 26G aluminium cladding.

e. PIPING INSULATION (Outdoors on Terrace/In shafts/ in AHU rooms/for AHU's) – with PUF insulation:
30 / 40 / 50 / 65 mm thick PUF insulation etc., 36 kg / M³ density with Aluminium foil with 50 mm overlap on joints and fixed with self adhesive aluminium tape & wrapping the insulation with 2 layers of 500 micron polythene sheet with PVC tape & additionally tying with fine aluminium wire and covered with 26G aluminium cladding.

f. MEASUREMENT OF INSULATION

1. **Insulation of Chilled Water / Drain Water Pipes:**

- Insulation of pipes shall be measured in terms of linear length of pipe for each size along the centre line of the installed pipe.
- For insulation of bends, elbows, tees etc. it shall be measured along with the center line of insulation and shall be measured in meters, and shall be measured as part of piping, and nothing extra to be charged for these.
- Insulation of valves shall be separately accounted as per bill of quantities.
- Insulation of expansion tank shall be accounted separately as per BOQ.

2. **Acoustic Lining of Duct & Plenum:**

This shall be measured on the basis of bare duct surface area i.e. the area of duct lining & area of duct shall be same.

3. **Thermal Insulation of Ducts:**

This shall be measured on the basis of bare duct surface area excluding all openings for grilles & diffusers and including all flanges & dampers etc.

4. **Acoustic Insulation of AHU Room & DG Set Room & Under Deck Roof Insulation:**

This shall be measure on the basis of finished surface area of the wall & roof.

IV. PRE-INSULATING CHILLED WATER PIPING

PRE INSULATED CHILLED WATER PIPES

a. The pipe shall be MS ERW as specified in the Piping Section.

b. The pipe insulation shall be polyurethane foam with minimum density of 36 kg/cu m, 90% minimum closed cell content, minimum compressive strength of 2.7kg/cm2, and initial thermal conductivity of 0.02W/mK. The insulation shall completely fill the annular space between the service pipe and jacket and shall be bonded to both, the service pipe & jacket.

c. The cladding shall be spirally wounded of G.I. or Aluminium as specified in tender documents for pipes installed on surface.

d. For pipes installed on surface The insulation (PUF) shall be provided to the thickness with thickness of cladding as below:

S.No.	Dia. Of MS Pipe	Minimum Thickness of PUF in (mm)	Minimum Thickness of G.I. Cladding	Minimum Thickness of Al. Cladding
1.	20 mm	33	0.457mm (26g)	0.559mm (24g)
2.	25 mm	32	0.457mm (26g)	0.559mm (24g)
3.	32 mm	33	0.457mm (26g)	0.559mm (24g)
4.	40 mm	30	0.457mm (26g)	0.559mm (24g)
5.	50 mm	31	0.457mm (26g)	0.559mm (24g)
6.	65 mm	36	0.457mm (26g)	0.559mm (24g)
7.	80 mm	42	0.457mm (26g)	0.559mm (24g)
8.	100 mm	42	0.457mm (26g)	0.559mm (24g)
9.	125mm	41	0.457mm (26g)	0.559mm (24g)
10.	150 mm	41	0.457mm (26g)	0.559mm (24g)
11.	200 mm	52	0.457mm (26g)	0.559mm (24g)
12.	250 mm	62	0.457mm (26g)	0.559mm (24g)
13.	300 mm	51	0.457mm (26g)	0.559mm (24g)
14.	350 mm	46	0.457mm (26g)	0.559mm (24g)
15.	400 mm	46	0.457mm (26g)	0.559mm (24g)
16.	450mm	45	0.457mm (26g)	0.559mm (24g)
17.	500mm	57	0.559mm (24g)	0.711mm (22g)
18.	550mm	57	0.559mm (24g)	0.711mm (22g)
19.	600mm	57	0.559mm (24g)	0.711mm (22g)
20.	650mm	56	0.559mm (24g)	0.711mm (22g)
21.	700mm	56	0.559mm (24g)	0.711mm (22g)
22.	750mm	55	0.559mm (24g)	0.711mm (22g)
23.	800mm	55	0.559mm (24g)	0.711mm (22g)

e. Underground systems shall be buried in a trench of not less than 600 mm deeper than the top of the pipe & not less than 450mm wider than the combined OD of all piping systems. A minimum thickness of 600mm of compacted backfill over the top of the pipe is desirable.

f. Trench bottom shall have a minimum of 150mm of sand, pea gravel or specified backfill material, consolidated to suit operating weight & to act as a cushion for the piping.

g. For pipes buried in ground outer protective insulation jacket shall be seamless, extruded, black, UV resistant, high-density polyethylene (HDPE).

h. For leak identification purpose 2 wire dignostic wiring shall also be provided.

i. Fitting can be fabricated at site over the carrier pipe and correct quantity of PUF shall be poured manually.

j. Field joints insulation shall consist of **PUF** poured manually in a site-fabricated GI cladding fixed around the joint.

k. For pipes buried in ground minimum thickness of the **HDPE** jacket and PUF shall be as follows:

S.No.	MS Pipe dia. (mm)	PUF Thickness (mm)	Thickness of HDPE Cladding (mm)
1.	20 mm	29	2.5
2.	25 mm	36	2.5
3.	32 mm	31	2.5
4.	40 mm	36	2.5
5.	50 mm	37	3.0
6.	65 mm	39	3.0
7.	80 mm	43	3.0
8.	100 mm	40	3.2
9.	125mm	39	3.5
10.	150 mm	53	4.4
11.	200 mm	63	5.0
12.	250 mm	57	6.3
13.	300 mm	58	7.0
14.	350 mm	64	7.8
15.	400 mm	68	8.8
16.	450mm	77	9.8
17.	500mm	50	11.1
18.	550mm	65	11.1
19.	600mm	83	12.5
20.	650mm	58	12.5
21.	700mm	82	13.0
22.	750mm	104	15.0
23	800mm	79	15.0

INSULATION SPECIFICATIONS (IN BRIEF) IN TABULAR FORM

INTERNAL ACOUSTIC LINING OF DUCTS	
Option-1 (with fibre glass board)	12mm thick, 48 kg / m³ resin bonded fibre glass board with one side factory laminated black glass cloth & & other side with aluminium foil. (Pasted with adhesive or screwed to duct surface.) Black glass cloth shall be visible from inside the duct.
Option-2 (with open cell nitrile rubber)	15mm thick, open cell nitrile rubber of 140-180 kg/m³ density. Class 1, (Pasted with adhesive to duct surface with rubber based solvent).

ACCOUSTIC LINING OF AHU ROOM's / DG SET ROOM's	
Option-1 (with fibre glass board)	25mm thick, 70 to 80 kg/m³ resin bonded fibre glass board with one side black glass cloth & other side with aluminium foil. Fixed with screws. Black glass cloth shall be visible from inside the AHU room.
Option-2 (with open cell nitrile rubber)	25mm thick open cell nitrile rubber of 140-180 kg / m³ density. Class-1.To be pasted with adhesive & use of fasteners.

Thermal insulation of ducts		
Descriptions	**With Fibre Glass Wool**	**With Nitrile Rubber**
Supply Air Duct in Air Conditioned Space – Indoor, when supply air duct is surrounded by cool return air	25mm thick resin bonded fibre glass of 32 kg / m³ density with one side WMPVR R PLUS (Tough guard) and other side black glass tissue. Fixing with CPRX compound on duct.	13mm thick nitrile rubber, 40-60 kg / m³ density Class 'O', fixed with adhesive. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).
Return Air duct in air conditioned space – Indoor (This may not be any case)	25mm thick resin bonded fibre glass of 32 kg / m³ density with one side WMPVR R PLUS (Tough guard) and other side black glass tissue. Fixing with CPRX compound on duct.	9mm thick nitrile rubber, 40-60 kg / m³ density Class 'O', fixed with adhesive. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).
Supply air duct in un-conditioned space – indoor, when not surrounded by cool return air i.e. when return air is also ducted.	50mm thick resin bonded fibre glass of 32 kg / m³ density with one side WMPVR R PLUS (Tough guard) and other side black glass tissue. Fixing with CPRX compound on duct.	25mm thick nitrile rubber, 40-60 kg / m³ density Class 'O', fixed with adhesive. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).
Return air duct in un-conditioned space – indoor	25mm thick resin bonded fibre glass of 32 kg / m³ density with one side WMPVR R PLUS (Tough guard) and other side black glass tissue. Fixing with CPRX compound on duct.	13mm thick nitrile rubber, 40-60 kg / m³ density Class 'O,' fixed with adhesive. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).
Supply air duct - Outdoor: - On Terrace - In shafts • TFA Supply Air Duct on Terrace & in Shaft. • HRW cum TFA Supply Air Duct on Terrace & in shaft. • AC Supply Air Duct on terrace / in open / in shaft.	50mm thick resin bonded fibre glass of 32 kg / m³ density with one side aluminium facing and other side black glass tissue. Fixing with CPRX compound on duct + UV Protective coating.	25mm thick nitrile rubber, 40-60 kg / m³ density with factory laminated 7ml UV treated glass cloth, Class 'O', fixed with adhesive & finished. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).
Return air duct - Outdoor - On Terrace - In shafts • Toilet exhaust duct in shaft & on terrace and entry into HRW cum TFA. • Toilet exhaust duct in shaft & on terrace and entry into HRW. • Pantry exhaust duct in shaft & on terrace and entry into HRW cum TFA.	25mm thick resin bonded fibre glass of 32 kg / m³ density with one side aluminium facing and other side black glass tissue. Fixing with CPRX compound on duct + UV Protective coating.	13mm thick nitrile rubber, 40-60 kg / m³ density with factory laminated 7ml UV treated glass cloth, Class 'O', fixed with adhesive & finished. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).

Thermal insulation of ducts		
Descriptions	**With Fibre Glass Wool**	**With Nitrile Rubber**
• Pantry exhaust duct in shaft & on terrace and entry into HRW. • Relief Exhaust duct in shaft & on terrace and entry into HRW cum TFA. • Relief Exhaust duct in shaft & on terrace and entry into HRW. • HRW supply air duct on terrace and in shaft.		

Underdeck insulation of Exposed roof:

Roof insulation (under deck)	
Option-1 (As per ECBC) (with Fibre Glass Wool Board)	75mm thick, 70-80 kg / m³ density glass wool board with one side aluminium faced & other side black glass tissue. Fixed with screws.
Option-2 (Non ECBC) (with Fibre Glass Wool Board)	50mm thick, 70-80 kg / m³ density glass wool board with one side aluminium faced & other side black glass tissue. Fixed with screws.
Option-3 (Non ECBC) (with Nitrile Rubber)	25mm thick, 40-60 kg / m³ density, Class 'O' Nitrile Rubber sheet fixed with adhesive.
Option-4 (Non ECBC) (with Extruded Polystyrene)	40mm thick, 32-35 kg / m³ density, Extruded Polystyrene (XPS) insulation board fixed with CPRX compound & chicken wire mesh netting.
Option-5 (Non ECBC) (with TF Quality Expanded Polystyrene)	50mm thick, 32 kg / m³ density, TF quality expanded polystyrene sheet screwed with CPRX compound & then with dash fasteners.

CHILLED WATER PIPING INSULATION				
	Fibre Glass Wool Pipe section	**Nitrile Rubber**	**TF Quality Exposed Polystyrene**	**PUF**
CHW pipes with in AC plant room	With fibre glass wool Pre formed pipe section with factory laminated aluminium facing, 2 layer of polythene sheet & 26G aluminium cladding	With nitrile rubber class"O"pipe sleeve or cut from sheets which have factory laminated UV and Mechanical protection. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).	With TF quality, 32 kg / m³ density pipe section or cut from slabs, 2 layer of polythene sheet & finished with 26G aluminium cladding	With PUF pipe section, 36 kg / m³ density, 2 layer of polythene sheet & finished with 26G aluminium cladding
CHW pipe on terrace - Exposed & in shafts and inside building above false ceiling spaces	With fibre glass wool Pre formed pipe section with factory laminated aluminium facing & UV protective coating	With nitrile rubber class "O" pipe sleeve or cut from sheets which have factory laminated UV and Mechanical protection. Insulation joints shall be sealed with 6mm thick, 50mm wide, self adhesive nitrile rubber strip (no PVC tape jointing).	With TF quality, 32 kg / m³ density pipe section or cut from slabs, 2 layer of polythene sheet, chicken wire mesh & finished with sand cement plaster.	With PUF pipe section, 36 kg / m³ density, 2 layer of polythene sheet & finished with 26G aluminium cladding
Chilled water piping buried in ground	With fibre glass wool Pre formed pipe section with factory laminated aluminium facing, 2 layer of polythene sheet, chicken wire mesh & finished sand cement plaster		With TF quality, 32 kg / m³ density pipe section or cut from slabs, 2 layer of polythene sheet, chicken wire mesh & finished with sand cement plaster.	With PUF pipe section, 36 kg / m³ density, 2 layer of polythene sheet, chicken wire mesh & finished with sand cement plaster.

SUBHEAD-I. PIPING

1. SCOPE

The scope of this section comprises the supply and laying of pipes, pipe fittings and valves, testing and balancing of all water and refrigerant piping required for the complete installation as shown on the Drawings. All piping inclusive of fittings and valves shall follow the applicable Indian Standards. Welders used for piping erection shall be well qualified and certified.

2. PIPE SIZES

Pipe sizes shall be as required for the individual fluid flows. Various pipe sizes have been indicated on the Drawings, these are for Contractor's guidance only and shall not relieve contractor of responsibility for providing smooth noiseless balanced circulation of fluids.

3. CHILLED, HOT AND CONDENSER WATER PIPING

a. The pipes, fittings and valves shall be of approved make given in the tender and shall be designed for a working pressure 16 Kg/ cm^2/ more if specified differently in the BOQ

Chilled / Condenser / Hot water pipes shall be "Heavy duty" MS Class "C" Black pipes up to 150 mm shall conform to IS:1239 (Part 1) -2004 and MS ERW Black Pipes above 150 mm shall conform to IS:3589 – 2001 Grade Fe 330 with latest amendments. The wall thickness of "Heavy duty" M.S. Class "C" Black pipes & MS ERW Black Pipes shall be as follows:-

	Nominal Pipe Dia	Wall Thickness of
a)	15	3.2
b)	20	3.2
c)	25	4.00
d)	32	4.00
e)	40	4.00
f)	50	4.50
g)	65	4.50
h)	80	4.80
i)	100	5.40
j)	125	5.40
k)	150	5.40
l)	200	6.30
m)	250	6.30
n)	300	7.10
o)	350	8.00
p)	400	8.80
q)	450	10.00 / 9.5mm
r)	500	10.00 / 9.5mm
s)	600	10.00 / 9.5mm

Drain water / make up water pipes shall be "B" Class GI Pipe & shall Conform to IS: 4736.
The pipes shall be sized for individual liquid flow & shall ensure smooth noiseless balanced circulation of fluid.
All jointing in the pipe system shall generally be by welding, unless otherwise mentioned, or directed at site. All welding shall be done by qualified welders and shall strictly conform to BIS Code of practice for manual metal arc, welding of Mild Steel.

b. All welded joints (except pipe welded end-to-end) shall be made by use of one-piece welding flanges, caps, nozzles, elbows, branch outlets and tees of approved make. Cut samples shall be submitted for approval, if directed. All such fittings etc., shall be of a type which maintain full wall-thickness at all points, simple radius and fillets, and proper bevels or shoulders at ends. All job welding shall be done by the electric arc welding process in accordance with the following:

- All joints shall have 45 degree bevel type, pipe mill-beveled or machine-beveled by the contractor.
- All scale and oxide shall be removed with hammer, chisel or file and bevel left smooth and clean.
- Pipe lengths shall line up straight with abutting pipe ends concentric.
- Both conductors from the welding machine shall be extended to locations at which welding work is being done. The leads from welding machine to location of welding work shall be held together with tape or other approved means so as to prevent induced current in structural steel, in piping or in other metals within the building. The ground lead shall be connected to length of pipe through joints in pipe, structural steel of building or steel pipe supports.

c. All pipes shall be thoroughly cleaned and given one primary coat of epoxy paint over epoxy primer before being installed. For vibration isolators pre-moulded polyurethane pipe sections of 160 Kg/m^3 density with adhesive shall be fixed between pipe and MS support. 10 mm thick MS 'U' clamp with resistoflex shall be fixed on the pipe so that the pipe is kept in position. All welded piping shall be subject to the approval at site. All supports should be factory fabricated from same manufacturer.

d. Fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type. These shall form part of piping and are not separately identified in Schedule of Quantities.

e. Tee-off connections shall be through equal or reducing tees, otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

f. **Ball and butterfly valves** conforming to the following specifications shall be provided as shown on Drawings:

Size	Construction	Ends	Type
15 to 40 mm	Brass ASTM B62	Screwed	Ball
50 mm and over	Body Cast iron, / Ductile iron	Wafer	Butterfly

Type and requirements shall be as indicated in Schedule of Quantities. Valves shall have non-rising spindles unless specified otherwise and shall be suitable for pressure rating as specified in the Schedule of Quantities.

Working Pressure:
Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

g. **Butterfly valves:**

Butterfly valves as per IS:13095
PN10 & PN16
Lever type up to 150mm & gear type above 150mm

Body: CI Epoxy Powder coated
Disc: DI
Liner: Replaceable EPDM

Butterfly valves as per IS:13095
PN20
Lever type up to 150mm & gear type above 150mm
Body: DI Epoxy Powder coated
Disc: DI
Liner: Replaceable EPDM

Butterfly valves as per IS:13095
PN25
Lever type up to 150mm & gear type above 150mm
Body: DI Epoxy Powder coated
Disc: DI
Liner: Replaceable EPDM

Working Pressure:
Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

h. **Manual double regulating balancing valves** shall have built-in pressure-drop measuring facility to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation. To enable accurate and practical operation, measurement of flow and differential pressure shall be made with a computerized balancing instrument which shall enable the operator to read the flow directly without the use of diagrams or tables. In addition to measuring flowrate, differential pressure and temperature, computerized balancing instrument shall have a computer programme to provide the following functions:

i. To balance the HVAC installation and calculate the necessary valve settings based on system measurements.
ii. To store the results of balancing.
iii. To log measured values from a valve (differential pressure, flowrate or temperature).
iv. To printout saved data in computerized measurement protocol (CMP) consisting of
- Name and size of Balancing Valve (BV)
- Presetting position of BV
- ΔP at BV
- Flow at BV
- Design Flow

Working Pressure:
Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

i. Automatic Balancing Valves
Automatic Balancing Valves Class 150 Wafer

1. Valve shall consist of dynamic, flow limiting device.

2. VALVE HOUSING

2.1. Class 150 Wafer valve housings shall consist of Grey iron (ASTM A126-61T, Class 30); shall be rated at 1400 kPa / 120°C; shall have single or multiple, parallel-installed stainless steel cartridge assemblies, (noted in section 3.0), to provide rated flow rate. Valve shall include all plated steel studs required for installation.

2.2. Valve shall be permanently marked to show direction of flow; shall have body tag to indicate model number, flow rate and DP control range.

2.3. Sizes 80mm (3") through 600mm (24") shall be mechanically compatible with ANSI B/16.l-1967 125 lb. cast iron flanges, ANSI B 16.5-1968 800mm (30") shall be compatible with MSS-SP-44 150 lb. steel flanges.

2.4. Sizes 400mm (16") and larger shall be provided with eyelet bolts for lifting.

3. FLOW REGULATOR / AUTOMATIC BALANCING UNIT

3.1. Flow regulation cartridge assembly shall be precision ground, all AISI type 300 Series stainless steel; shall be available in four kPaD control ranges; minimum range shall be capable of being activated by less than 10 kPa; and shall be capable of controlling flow within +/-5% of rated flow.

3.2. Dual pressure or pressure/temperature test valves for verifying accuracy of flow performance shall be provided for all valve sizes.

4. ACCESSORIES

4.1 Identification tags shall be available for all valves.

Working Pressure:

Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:

Test pressure shall be 1.5 times of the working pressure.

J. 2 Way Modulating Pressure Independent Dynamic Balancing cum Flow Control Valve

1. PRESSURE INDEPENDENT DYNAMIC CONTROL VALVE FLOWCON SM

1.1. Valve shall be electronic, dynamic, modulating, 2-way, control device.

1.2. Dynamic control valve shall accurately control flow, independent of system pressure fluctuation.

1.3. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size.

2. VALVE ACTUATOR

2.1. Valve actuator housing shall be rated to IP 44.

2.2. Actuator shall be driven by a 22-26V AC or 28-32V DC motor, and shall accept 2-10 VDC, 0-10 VDC, 4-20 mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.

2.3. Actuator shall be capable of providing 4-20 mA or 2-10V DC feedback signal to the control system.

2.4. External LED read-out of current valve position and maximum valve position setting shall be available.

3. VALVE HOUSING

3.1. Housing for 15 – 40 mm size shall be constructed of forged ASTM (CuZn39Pb2) brass rated at no less than 2500 kPa static pressure and 120°C.

3.2. Housing for 50 – 150 mm shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 4000 kPa static pressure and 120°C.

3.3. Valve housing for 15 – 40 mm shall be double union construction with a range of pipe connections available for the appropriate pipe size.

3.4. Identification tags shall be available for all valves.

4. FLOW REGULATION UNIT

4.1. Flow regulation unit shall consist of stainless steel and hydrogenated acrylonitrile butadiene rubber and shall be capable of controlling flow within +/- 5% of each rated flow.

4.2. Flow regulation unit shall be accessible, for maintenance.

4.3. Optional dual pressure/temperature test plugs for verifying accuracy of flow performance shall be available for all valve sizes.

Working Pressure:

Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:

Test pressure shall be 1.5 times of the working pressure.

k. ON/OFF TEMPERATURE CONTROL / FLOW RATE LIMITING VALVES

1.1. The control valve and the flow-limiting device shall be available as a plug-in device for an in line valve housing.

2. VALVE HOUSING

2.1. The housing shall be constructed of Forged Brass ASTM B584, rated at no less than 1600 kPa static pressure at 100ºC.

3. CONTROL VALVE

3.1. Actuator shall provide of a visual indication of the valve position.

3.2. The valve shall be closing when the actuator is not powered.

3.3. The valve shall withstand a shut off pressure of at least 400 kPa without allowing internal leaking.

3.4. The seat plug shall be manufactured of EPDM rubber.

3.5. The packing box for sealing the stem shall be removable with the system in operation, without allowing external leakage.

4. FLOW REGULATOR

4.1. Valve shall consist of dynamic, flow limiting device.

4.2. The flow regulator shall be constructed of stainless steel AISI Type 304.1

Working Pressure:

Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:

Test pressure shall be 1.5 times of the working pressure.

l. MANUAL BALANCING VALVES

Balancing Valves Rating PN-10 / PN-16

These valves shall have built in pressure drop measuring facility to compute flow rate across the valve. The test cocks shall be long enough to protrude out of pipe insulation. To measuring flow rate, differential pressure will be measured with calibrated instruments – Digital or Mercury Manometer. Balancing Tools shall have a programme to provide the following functions:

- To balance the HVAC installation and calculate the necessary valve settings based on the systems data as observed prior to balancing exercise.
- To log measured values from a valve (differential pressure and flow rate)
- To store the results of balancing
- To printout saved data in computerized measurement protocol (CMP) consisting of :
- Name and Size of Balancing Valves
- Presetting position of Balancing Valves
- Design Flow for each Balancing Valves
- Flow at Balancing Valves
- Flow Ratio pre-balancing based on actual flow / design flow
- Flow Ratio post-balancing and Actual Flow

The balancing valves of size 25mm to 50mm dia shall be of Gun Metal Construction with screwed ends. Whereas Valves of size 65mm to 300mm shall be of cast iron Flanged Construction.
The detailed material of construction shall be as given below :

Balancing Valves 25mm to 50mm (Gun Metal Screwed End Construction)

Pressure Rating : PN-10 / PN-16
Style : Globe Type BSP Threaded Screwed End Construction
Body Test Pr. : 24 Bar (g)
Seat Test Pr. : 17.6 Bar (g)

Material of Construction :

Body : IS 318 LTB 2 (Gun Metal)
Bonnet : Size 25mm in Brass and 32mm-50mm in IS 318 LTB 2 (Gun Metal)
Plug : Size 25mm in Brass IS 319 and 32mm-50mm in IS 318 LTB 2 (Gun Metal)
Stem : IS 319 Type-I (Brass)
Temperature : -46 Degree C to 200 Degree C
Gland Nut : Brass
Hand Wheel : Nylon Gr. 66
Pressure Test Cocks : Brass

Balancing Valves 65 mm to 300mm (Cast Iron Flanged End Construction)

Pressure Rating : PN-10 / PN-16
Style : Globe Type Flanged End Construction
Body Test Pr. : 24 Bar (g)
Seat Test Pr. : 17.6 Bar (g)

Material of Construction :

Body : Cast Iron to IS 210 Gr. FG 260
Bonnet : Cast Iron to IS 210 Gr. FG 260
Hand Wheel : M S Fabricated
Stem : SS-410
Disc : SS-410
Sealing Disc : E P D M
Temp Range -40 Deg. C to 120 Deg. C)
Pressure Test Cocks : Steel Chrome Plated
End Connection : IS : 6392 Table 17

All valves shall be tested for flow vs. pressure drop within + 5% accuracy and data be furnished as part of Test Certificate.

Large Size Balancing Valves Size 350mm to 1000mm

Balancing valve with integral flow measuring & minimum 50 step flow regulation with locking and maximum set value stopper

Pressure Rating : PN-10 / PN-16

Face to face distance As per ISO 5752 Table-8

Regulating Device : High Performance (Double Eccentric) Butterfly Valve with special worm gear operator

Valve Configuration : Suitable for Mounting between flanges similar to wafer valves

Flow Measurement Accuracy : Within + 7% within operating range of 20 Deg to 70 Deg Opening

Flow Measuring Range : As per Graph given below

Flow Regulation Steps: Minimum 50 steps between 20 deg to 70 deg valve opening. The valve flow performance shall not be effected by other valves and fitting beyond 1D distance from valve face .

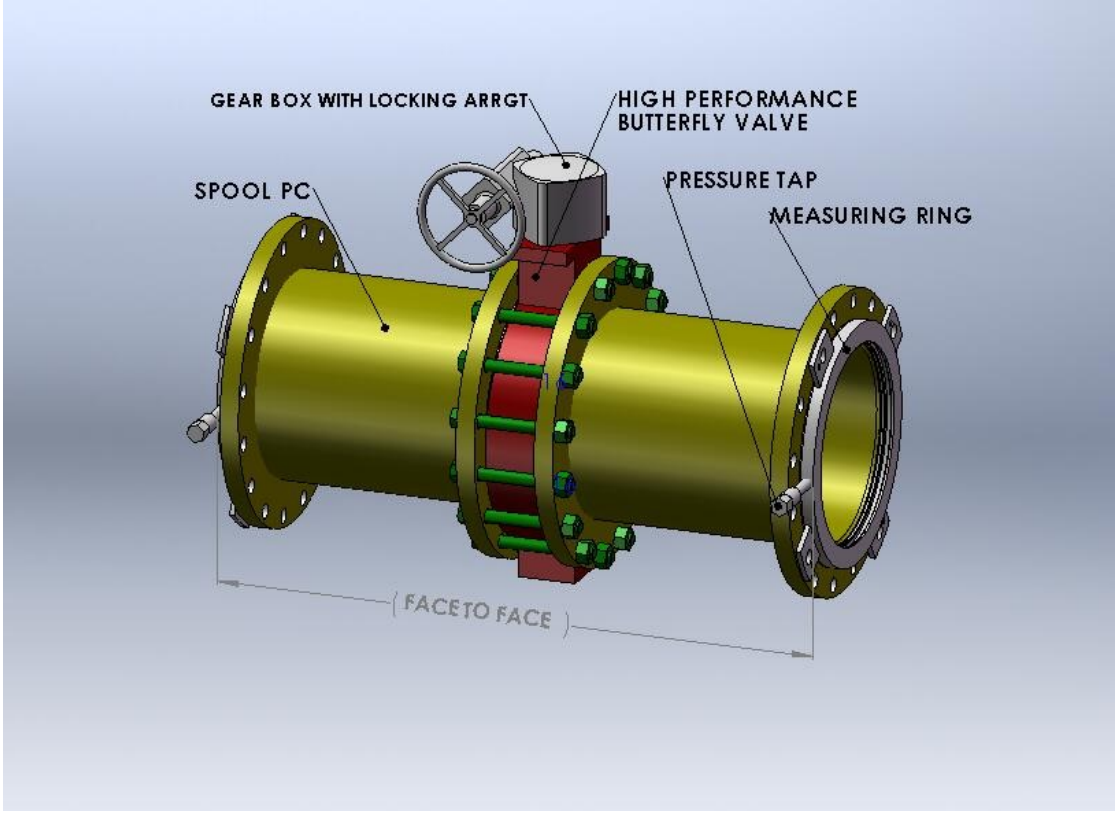
The valve shall be supplied with Guaranteed Kv value for all valve opening angles 20 to 70 Deg.

Material of Construction

Body	:	Cast Iron to IS 210 Gr. FG 260
Disc	:	Ductile (SG) Iron to IS 1865 Gr. 450/10 with Nylon Coated
Seal	:	EPDM elastomer
Stem	:	SS-431
Trim	:	SS-304 (CF8)
Measuring Ring:		SS-3014 (CF8)
Seat Test	:	17.6 bar kg/cm2
Shell Test	:	24 bar kg/cm2

Worm Gear Operated

Worm : SS 410



Balancing of the Water System :

The Balancing of water system is to be done by Contractor with the help of a software – package, digital differential pressure measuring instrument or Mercury Manometer.

m. **Flanges** shall be of approved make. The supply of flanges shall form part of piping (not separately identified in Schedule of Quantities) and shall also include supply of bolts, washers, nuts and suitable

asbestos fibre / rubber insertion gaskets (minimum 3 mm thick).

n. **All ball valves and ball valves with Y strainer** for FCU's and Chilled water cassettes shall be forged brass body (nickle plated) construction with forged brass ball (chrome plated) and handle of stainless steel constructions. These are separately identified in Schedule of Quantities.

Working Pressure:
Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

o. Non return valves shall be dual plate check valve provided as shown on the Drawings, and identified in Schedule of Quantities conforming to relevant Codes and in accordance with the following Specifications :

Size	Construction	Ends
50 to 150 mm	Body cast iron,	Flanged gun metal plate
200 mm to 450 mm	Body cast iron, plate 13% chrome overlay	Flanged carbon steel with

The spring and hinge/stop pin shall be SS304 and bearing PTFE material. Valves shall be PN 16 rating/ more if specified otherwise in the Schedule of Quantities.

Working Pressure:
Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm² / 150 PSI
- PN16 / 16 Kg per Cm² / 235 PSI
- PN25 / 25 Kg per Cm² / 367 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

p. **'Y' Strainer & Pot Strainer**

'Y' Strainer

'Y' Strainers shall be suitable for PN 10 or PN 16 or PN 25 pressure rating as included in BOQ. 'Y' Strainer shall be fabricated out of MS 'C' class pipe two sizes higher than that of Strainer pipe size. Flanges as per B.S. 10 shall be provided at inlet and outlet connections. The body shall be painted or hot dip galvanized. Permanent magnet shall be provided in the body of the Strainer to arrest iron particles. Filter element shall be of non-magnetic 20 gauge SS304 sheet with 3 mm perforation. Y Strainers shall be provided at inlet of each Air Handling Unit and Pump as shown in drawings and included in BOQ. Butterfly valves shall be provided at inlet / outlet connections of the 'Y' Strainer (butterfly valves not in the scope of Y Strainer supply). Filter element will be replaced after testing & commissioning so as to get good quality of water in system after commissioning.

Pot Strainers (with automatic back wash)

Pot Strainers body shall be fabricated out of MS plate IS 2062. Pot strainer shall be suitable for PN10 or PN16 or PN25 pressure rating as included in BOQ. Thickness of sheet shall be as per size

of the strainer chamfered pipes with flanges shall be provided at inlet /outlet connections of the strainer. The tangential entry of water shall create a centrifugal action and due to velocity shall separate sediments and deposit on the inner surface of Filter Element and at bottom of the Strainer. Butterfly valves shall be provided at inlet / outlet connections as shown in drawing and included in BOQ. The strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. A powerful magnet shall be provided in the body to arrest iron particles. Filter element of Pot Strainer shall be of non-magnetic 18 gauge SS304 sheet properly reinforced to avoid damage of the element with 3mm perforations. A cone with sufficiently large drain pipe with butterfly valve shall be provided at the bottom chamber to flush-out foreign particles. This arrangement shall avoid frequent opening of Pot Strainer for cleaning of filter element. Gauge connection shall be provided at inlet and outlet connection.

Pot strainers shall be provided with automatic backwash system if called for in BOQ. This shall be with heavy duty reduction gear motor provided at top of upper lid. During backwash, motorized drain valve shall be opened along with vent cock. Power supply cabling with tray shall be included in cost of pot strainer. Entire operation shall be through BAS. Motorized drain valve shall be included in the cost of the pot strainer. Motorized Butterfly valves shall be provided at the inlet & outlet of the pot strainer (not in the scope of pot strainer supply).

A set of MS flanges with tongue and groove arrangement and neoprene rubber gasket shall be provided on the top cover and Pot Strainer flange with sufficient bolts and nuts to make the joint water tight. Bearing loaded top cover lifting and swinging arrangement shall be provided. The Pot strainer body shall be properly de-rusted and epoxy coated from inside and outside.

Drawing and included in BOQ. The strainer body shall have two separate chambers properly sealed to avoid mixing of filtered and unfiltered water. This arrangement shall avoid frequent opening of Pot Strainer for cleaning of filter element. Gauge connection shall be provided at inlet and outlet connection. Bearing loaded tope cover lifting and swinging arrangement shall be provided. The Pot strainer body shall be properly de-rusted and epoxy coated from inside and outside. Manufacturers Test Certificate shall be provided with each Pot Strainer.

Note: It shall be complete with a control panel & wiring etc. to control automatic operation of inlet & outlet motorized butterfly valves, bypass motorized butterfly valve & drain line solenoid valve with a timer arrangement.

Size of various Pot Strainers and Thickness of MS sheet shall be as Under:

S. No	Pipe Size	Pot Dia	Pot	Element	Element	MS Plate
	mm	mm	Height	Dia	Height	thickness
			mm	mm	mm	mm
1	50	300	400	200	240	6
2	80	350	450	250	250	6
3	100	450	500	300	280	6
4	125	500	600	330	340	8
5	150	540	700	360	390	8
6	200	610	815	400	470	8
7	250	800	955	550	510	8
8	300	1000	1105	750	580	8

9	350	1190	1300	895	678	12
10	400	1350	1500	1020	785	12
11	450	1518	1700	1060	890	12
12	500	1690	1800	1100	900	12
13	600	2000	2200	1500	1160	12

Each Port strainer shall be provided with a Test Certificate.

Working Pressure:

Working pressure ratings shall be as follows but as specified in the schedule of quantities:

- PN10 / 10 Kg per Cm^2 / 150 PSI
- PN16 / 16 Kg per Cm^2 / 235 PSI
- PN25 / 25 Kg per Cm^2 / 367 PSI

Test Pressure:
Test pressure shall be 1.5 times of the working pressure.

q. All chilled water piping and fittings shall be pressure tested, painted and then insulated as described under the section "Insulation".

r. Grooved coupling: Grooved coupling shall have 3 main parts viz. Housing, Gasket and bolting arrangement. Housing shall be made out of ASTM-A 536 Grade 65-45-12. The housing key shall engage into the grooves around the full pipe circumference, securing the pipe ends together with positive grip. Housing shall be designed to provide optimum combination of pressure, stress relief and end load conditions while maintaining reasonable weight. Gasket shall be of high sealing efficiency and shall be able to withstand upto (-) 0.35 Bar pressure. Bolt shall confirm to ASTM A183, while nut shall confirm to ASTM A194. Nut-bolt shall be electro-galvanized.

All pipe / equipment connections with in the plant room shall be with Victaulic couplings.

4. Grooved Pipe Jointing System

a. References:

1. American Society for Testing Materials (ASTM)
a. ASTM A-53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
b. ASTM A-183 – Carbon Steel Track Bolts and Nuts
c. ASTM A-234 – Standard Specification For Piping Fittings or Wrought Carbon Steel and Alloy Steel.
d. ASTM A-449 – Quenched and Tempered Steel Bolts and Studs
e. ASTM A-536 – Ductile Iron Castings
f. ASTM F-1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

2. American Society of Mechanical Engineers
a. ASME B16.9 – Factory Made Wrought Butt Welded Fittings
b. ASME B31.1 – Chemical Plant and Petroleum Refining Piping
c. ASME B31.9 – Building Services Piping

3. American Water Works Association
a. AWWA C-606 – Grooved and Shouldered Joints

b. Quality Assurance

1. All grooved components (including couplings, fittings, valves and accessories) to be supplied by one manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

c. Grooved Mechanical Couplings for Joining Carbon Steel Pipe

1. Grooved Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa) as provided standard Victaulic.

a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.

b. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three Couplings shall be placed in close proximity to the vibration source.

2. Flange Adapters: For use with grooved end pipe and fittings, for mating to ANSI Class 150 flanges.

3. Grooved couplings shall meet the requirements of ASTM F-1476.

4. Gasket: Synthetic rubber, wide width, conforming to steel pipe outside diameter and coupling housing,

manufactured of elastomers as designated in ASTM D-2000.

D. Grooved End Fittings: Fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375" wall (9.53mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153. Zinc electroplated fittings and couplings conform to ASTM B633.

Grooved Hole-Cut Branch Outlets:

a. Bolted Branch Outlet: Branch reductions on 2"(DN50) through 8"(DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183.

b. Strapless Outlet: 1/2"(DN15) or 3/4"(DN20) NPT outlet on 4" (DN100) and larger header sizes rated for 300 PSI (2065 kPa).

c. Strapless Thermometer Outlet: To accommodate industrial glass bulb thermometers with standard 1-1/4"-18 NEF 2B extra fine thread and 6" (152mm) nominal bulb length on 4" (DN100) and larger header sizes rated for 300 PSI (2065 kPa).

5. COLD WATER AND DRAIN PIPING

a. All pipes to be used for cold water (makeup), drain, condensate drain and fittings shall be galvanized steel class `B' (medium class) conforming to relevant BIS Codes.

b. All jointing in the pipe system shall be by screwed joints and/or by screwed flanges using 3 mm 3 ply rubber insertion gaskets. Pipe threads and flanges shall be as per relevant BIS Codes.

c. All pipes supports shall be mild steel, thoroughly cleaned and given one primary coat of red oxide paint before being installed.

d. Fittings shall be galvanized steel `medium class' malleable casting of pressure rating suitable for the piping system. Flanges shall be of approved make. Supply of flanges shall include bolts, nuts, gaskets as required. Sufficient number of flanges and unions shall be provided for future cleaning and servicing of piping. Tee-off connection shall be through equal or reducing tees. All equipment and valve connections or connections to any other mating pipes shall be through flanges required for the mating connections. Fittings & flanges shall form part of piping and are not separately identified in Schedule of Quantities.

e. Gate valves, globe valves, check valves and strainers shall be similar to those specified for chilled, condensing and hot water piping.

f. For proper drainage of AHU Condensate, 'U' trap shall be provided in the drain piping.

g. All condensate drain piping shall be insulated and painted as per the section "Insulation" as indicated in Schedule of Quantities.

6. REFRIGERANT PIPING

a. All refrigerant pipes and fittings shall be hard drawn copper tubes and wrought copper / brass fittings suitable for connection with silver solder / phos-copper.

b. All joints in copper piping shall be sweat joints using low temperature brazing and / or silver solder. Before jointing any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using carbon dioxide / nitrogen.

c. Refrigerant lines shall be sized to limit pressure drop between the evaporator and condensing unit to less than

0.2 kg per sq.cm.

d. Sight glass with moisture indicator and removable type combination dryer cum filter with MS housing and brass wire mesh / punched brass sheet shall be installed in liquid line of the refrigeration system incorporating a three valve by pass. After ninety days of operation, liquid line drier cartridges shall be replaced.

e. Heat exchanger shall be MS heavy duty pipe in pipe type & without any joint in inner pipe.

f. Horizontal suction line shall be pitched towards the compressor and no reducers shall be provided for proper oil return.

g. After the refrigerant piping installation has been completed, the refrigerant piping system shall be pressure tested using Freon mixed with nitrogen / carbondioxide at a pressure of 20 kg per sq. cm (high side) and 10 kg per sq. cm (low side). Pressure shall be maintained in the system for a minimum of 12 hours. The system shall then be evacuated to a minimum vacuum of 70 cm of mercury and held for 24 hours. Vacuum shall be checked with a vacuum gage.

h. All refrigeration piping shall be installed strictly as per the instructions and recommendations of air conditioning equipment manufacturer.

7. PIPING INSTALLATION

a. Design Drawings indicate schematically the size and location of pipes. The Contractor, on award of the work, shall prepare detailed shop drawings, showing the cross-section, longitudinal sections, details of fittings, locations of isolating and control valves, drain and air valves, and all pipe supports. He must keep in view the specific openings in the building through which pipes are designed to pass.

b. Piping shall be properly supported on, or suspended from, stands, clamps, and as required. The Contractor shall adequately design all the brackets, saddles, anchors, clamps and hangers and be responsible for their structural sufficiency. All such supporting arrangement shall be cleaned for rust, primer coated and suitably painted.

All pipes in HVAC plant room shall be supported with pipes and channels from floor only with necessary PUF pipe supports and resistoflex sheet.

c. Pipe supports shall be of adjustable for height and epoxy painted over epoxy primer coated with rust preventive paint and finish coated black . Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between.

d. Vertical pipes passing through floors shall be plumb and parallel to wall. Pipes shall be supported on alternate floor. MS cleats shall be welded on pipes and rest on MS channel placed on the floor with 15 mm thick resistoflex pads between the cleat and channel. U clamps with resistoflex sheet shall be provided to keep the pipe in position.

e. Bull heading in water/refrigerant piping shall be avoided.

f. Pipe sleeves atleast 3 mm thick, 50 mm / 100 mm larger in diameter than condenser/ chilled water pipes respectively shall be provided wherever pipes pass through retaining wall and slab. Annular space shall be filled with fibreglass and finished with retainer rings welded on the ends of the sleeve.

g. Wherever pipes pass through the brick or masonry / slab openings, the gaps shall be sealed with fire sealant such as fire barrier caulks.

h. Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 20 gage metal sheet shall be provided between the insulation and the clamp, saddle or roller, extending atleast 15 cm on both sides of the clamp, saddles or roller.

i. All piping work shall be carried out in a workmen like manner, causing minimum disturbance to the

existing services, buildings and structure. The entire piping work shall be organized, in consultation with other agencies work, so that laying of pipes, supports, and pressure testing for each area shall be carried out in one stretch.

j. Cut-outs in the floor slabs for installing the various pipes are indicated in the Drawings. Contractor shall carefully examine the cut-outs provided and clearly point out where the cut- outs shown in the Drawings do not meet with the requirements.

k. The Contractor shall make sure that the clamps, brackets, clamp saddles and hangers provided for pipe supports are adequate. Piping layout shall take due care for expansion and contraction in pipes and include expansion joints where required.

l. All pipes shall be accurately cut to the required size in accordance with relevant BIS Codes, edges bevelled and burrs removed before laying. Open ends of the piping shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.

m. Flanged inspection pieces 1.5 meters long, with bolted flanges on both ends, shall be provided no more than 30 meters centres, or where-ever shown in Approved-for- Construction shop drawings, to facilitate future cleaning of all welded pipes.

n. All buried pipes shall be cleaned and coated with zinc chromate primer and bitumen paint, and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters and wrapped with three layers of fibre glass tissue, each layer laid in bitumen.

o. Insulated buried pipes shall be cleaned, derusted, then coated with rust-resistant primer and placed on concrete blocks with PUF saddles dipped in bitumen at every 2 meters. Insulation shall be applied as per the section “Insulation”, wrapped with GI wire and covered with polyethylene sheet. Two coats (each 6 mm thick) of cement plaster shall be applied over chicken wire mesh lath. Where indicated in Schedule of Quantities, buried insulated pipes shall be water-proofed using coat of Shalibond, or approved adhesive, over the plastered surface; wrapping one layer of fibre glass RP tissue and one layer of roofing tarfelt with sufficient overlaps, set and sealed with the adhesive, held in position by 16 gage G.I wire tied at 15 cm intervals.

p. Auto purge valves shall be provided at all highest points in the piping system for venting air. Air valves shall be 15 mm pipe size with screwed joints.

Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.

7.1 Pipe Support as per NBC-2016, Par 8, Section 3 Clause 12.1.8 & Table 13 (Page 64 & 65)

NBC Clause 12.1.8: Installation of Piping Works

Design, choice of materials, and the installation of chilled water/condenser water/drain water pipes, pipe fittings and valves shall conformed to relevant Indian Standards and shall meet the requirements of pressure rating for the system.

Chilled/condenser/hot water pipes of sizes up to 150 mm shall be heavy class, ERW mild steel black pipes conforming to the accepted standard [8-3(14)] and those of sizes above 150 mm shall be ERW/SAW pipes of Grade 330 conforming to the accepted standard [8-3(15)].

Piping shall be properly supported on, or suspended from, stands, clamps, springs, hangers, as required at site. Design of all the brackets, saddles, anchors, clamps and hangers shall be as per requirement identified by the system designer.

All pipes within HVAC plant room shall be supported off the floor of the plant room, and rest from the ceiling, with engineered support structures made of pipes and channels, with pipe always resting on the

necessary high density PUF/wooden haunches. Minimum requirements in respect of support details, for horizontal and vertical chilled water pipes with mild steel channel and angle sections, are given in Table 13.

The recommended spacing between supports for various pipe sizes are given below:

Pipe Size MM	Spacing Between Supports M
Up to 12	1.5
15 to 25	2.0
30 to 250	2.0
Above 250	2.5

All pipe supports shall be of steel, coated with two coats of anti-corrosive paint and finally finished with epoxy paint.

Where pipe and clamps are of dissimilar materials, a gasket shall be provided in between.

Vertical pipes passing through floors shall be parallel to wall and should be straight to wall duly checked with plumb line.

Wherever pipes pass through the brick or masonry/slab openings, the gaps shall be properly sealed as per the provisions given in Part 4 .Fire and Life Safety. of the Code.

Wherever insulated pipes are installed, pipes should be supported in such a way that no undue pressure is exerted on the insulation material.

Piping layout shall take due care of expansion and contraction in pipes, and shall include expansion joints, where required.

All pipes shall be accurately cut to the required size in accordance with relevant Indian Standards, edges beveled and burrs removed before laying. Open ends of the piping section shall be closed as the pipe is installed to avoid entrance of foreign matter. Where reducers are to be made in horizontal runs, eccentric reducers shall be used for the piping to drain freely. In other locations, concentric reducers may be used.

Auto purge valves shall be provided at all highest points in the piping system for venting air. Air valves shall be
15 mm pipe size with screwed joints. Discharge from the air valves shall be piped through an equal sized mild steel or galvanized steel pipe to the nearest drain or sump. These pipes shall be pitched towards drain points.

Drain pipes shall be provided at all the lowest points in the system, as well as at equipment where leakage of water is likely to occur, also to remove condensate and water from pump glands. The drain pipe work can be carried out with threaded joints or simply welded.

Table 13 Support Details for Chilled Water Pipe
(*Clause* 12.1.8)
All dimensions in millimetres.

Sl No. (1)	Pipe Size (2)	Ceiling Support (3)	Base Support (4)	MS Plate Size (5)	Fastener Size (6)
i)	Horizontal chilled water pipe support (for one pipe):				
a)	Up to 50	40 × 40 × 5 thick angle	40 × 40 × 5 thick angle	Cleat ISA 75 × 75 × 5	M10 × 2 numbers
b)	65 to 125	50 × 50 × 6 thick angle	75 × 40 MS channel	250 × 250 × 8 thick	M10 × 4 numbers
c)	150 to 250	75 × 40 MS channel	100 × 50 MS channel	250 × 250 × 8 thick	M10 × 4 numbers
d)	300 to 350	100 × 50 MS channel	150 × 75 MS channel	300 × 300 × 10 thick	M12 × 4 numbers
e)	400 to 500	100 × 100 × 6 MS channel box	150 × 150 × 6 MS channel box	400 × 400 × 10 thick	M16 × 4 numbers
f)	600 to 700	150 × 150 × 6 MS channel box	150 × 150 × 6 MS channel box	400 × 400 × 12 thick	M16 × 4 numbers
ii)	Vertical chilled water pipe support (for one pipe):				
a)	65 to 125	—	75 × 40 MS channel	250 × 250 × 8 thick	M10 × 4 numbers
b)	150 to 250	—	100 × 50 MS channel	250 × 250 × 8 thick	M10 × 4 numbers

7.2 Pipe Support system with Steel Wire Rope Hangers & Supports:

Wire Hangers shall be used to suspend all static HVAC & Mechanical services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10,M12) stud/eyebolt, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking grip (double channel wedge type lock) at the other end. Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip. In case unlocking arrangement is an integral part ie. button/pin type, the button/pin shall be hidden under a separate housing cover made of same material as of housing. To guard against accidental unlocking, the unlocking button/pin should be accessible if and only if the housing cover is removed. Only wire and/or supports supplied and/or approved, shall be used with the system.

Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, CSA, ADCAS, Intertek, ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002 standards. If product is not certified by SMACNA and manufacturer is giving compliance to SMACNA then the wire dia. Selection shall be as mentioned in SMACNA Chapter 5, Tables 5-1, 5-1M, 5-2 and 5-2M.

Wire Hangers shall be independently tested by reputed third party testing organization to sustain safe working load for 120min at elevated temperature of 175 deg. C or above.

The contractor shall select the correct specification of wire hanger to use for supporting each particular service. Each size should be designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required should be determined using the following formula or as per manufacturer's recommendation, whichever is stringent.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook. The contractor shall select the correct length of wire rope required to support the service. No in–line joints should be made in the rope.

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302, BSEN12385. Comply with manufacturer's load ratings and recommended installation procedures. The testing shall be done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

Mechanical Supports – Hanger Supports shall be suitable for: Water Pipes, Drainage Pipes, Gas Pipes, Refrigeration Pipes, Condensation Water Pipes, Chilled Beams, Heater, Ceiling Grid, Suspended Ceiling and Acoustic Baffle:

a. **Piping Supports:** Rigid supports may be used in conjunction with hangers to assist with alignment of services as per the Schedule. These can be at 30m intervals or so depending on the run of the service. Rigid support must also be used in conjunction with hangers with pipework as per support GFC/design drawings. For insulated pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.
b. Any other solution can be used based on manufacturer's recommendation on site conditions after prior approval. Support piping in accordance with Schedule at the end of this Section.
c. For insulated pipe, provide protective sleeve to protect the entire circumference of the pipe insulation. Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

Refer to manufacturers catalogue and installation guide for further technical information. **Comply with manufacturer's load ratings and recommended installation procedures. All supporting system to be provided by same manufacturer.**

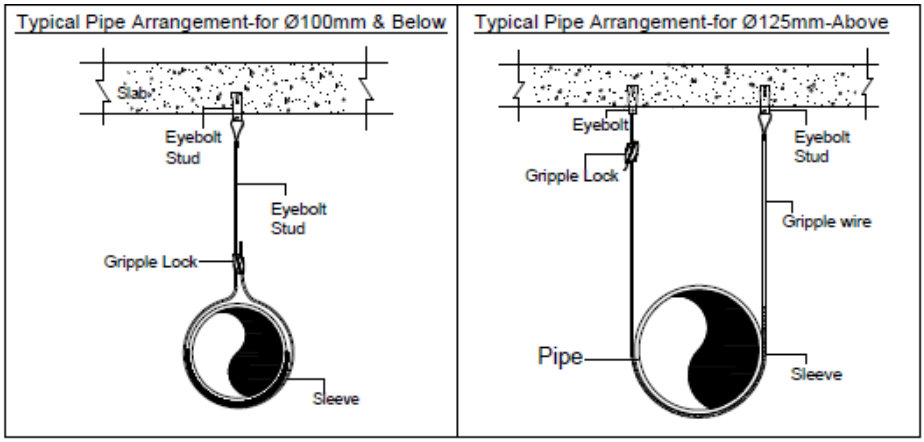
Rigid Supports for pipes to be used in conjunction with wire supports:
Rigid supports if required in conjunction with wire hangers shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black, Galvanized Modular Strut support system of required strength and profile can also be used. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between.

PIPE SIZE (mm)	PIPE SUPPORT
UP TO 50 Ø	40×40×6 M.S ANGLE
80Ø TO 100Ø	50×50×6 M.S ANGLE

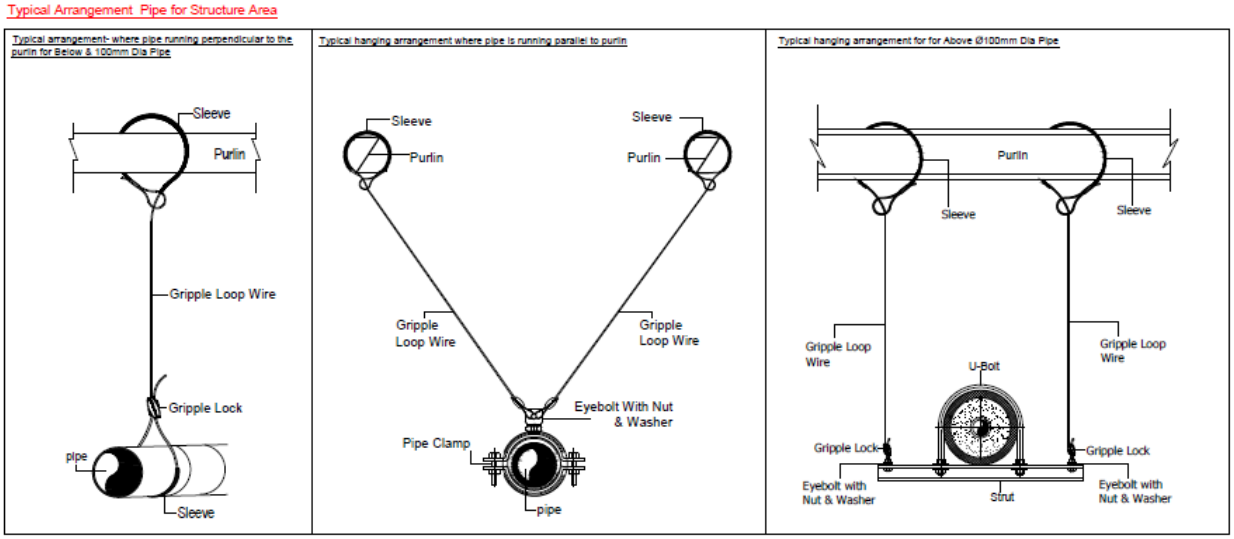
PIPE SIZE (mm)	HORIZONTAL SUPPORT	VERTICAL SUPPORT
250Ø TO 300Ø	100×50 M.S CHANNEL	75×40 M.S CHANNEL
300Ø TO 400Ø	150×75 M.S CHANNEL	100×50 M.S CHANNEL
450Ø TO 600Ø	200×75 M.S CHANNEL	200×75 M.S CHANNEL

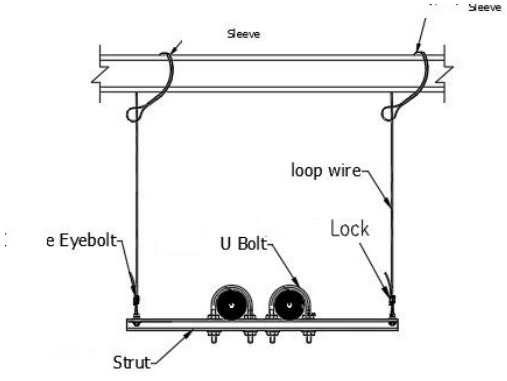
Note: Contractor shall be fully responsible & accountable for the structural stability of the hanging / supporting system of duct work. The above data furnished about supports is only for guidance. The ducting contractor to hire a specialist agency / vendor to design the supporting system of duct work and submit a design & certificate along with supporting marked drawings with typical supporting arrangements.

7.2.1 Typical arrangement for Support from RCC Slab:



7.2.2 Typical arrangement for Support from PEB:





7.2.3 Typical arrangement for Support from building shaft:

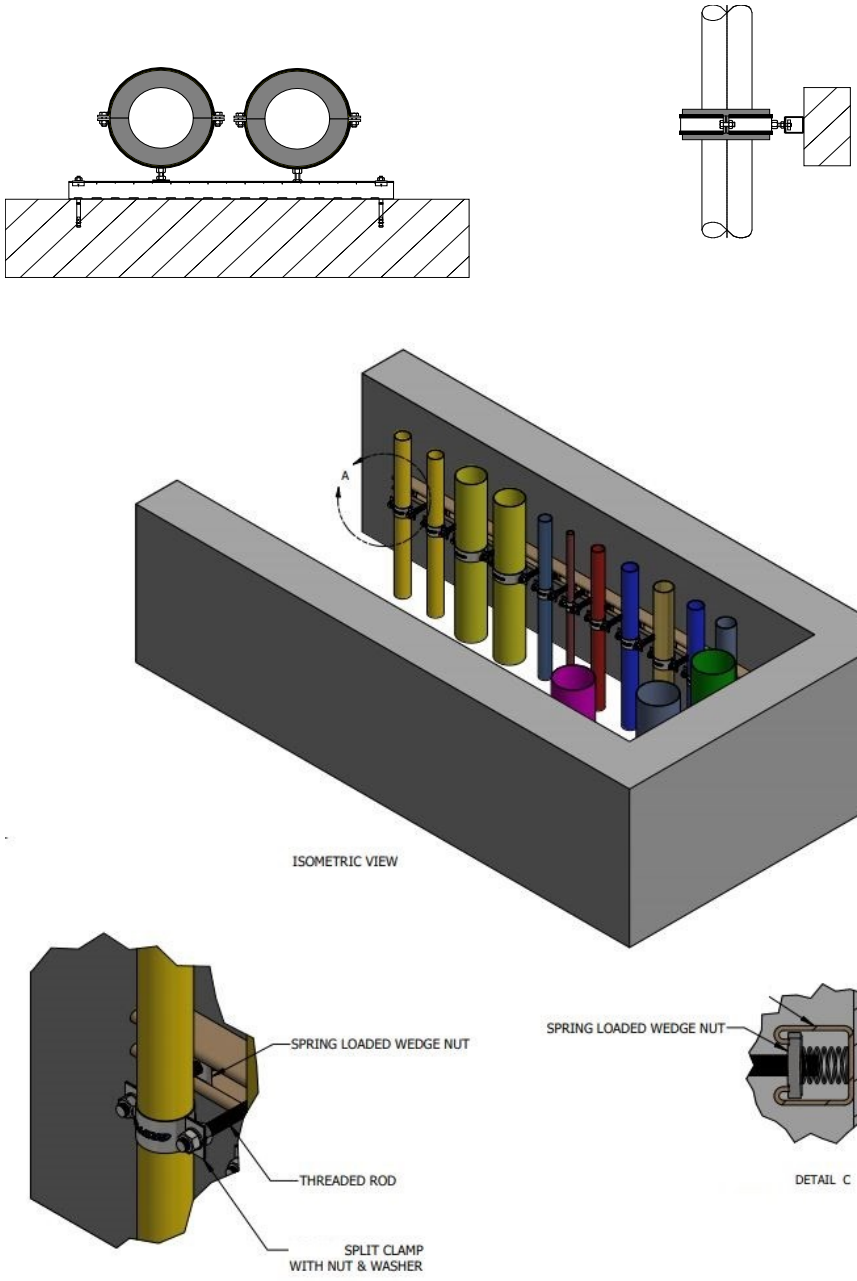
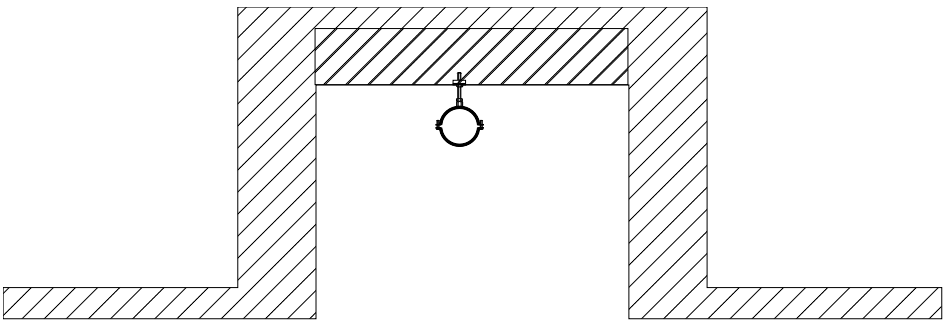
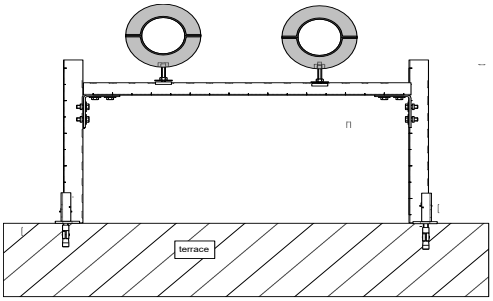


Fig: Support for CHW pipe



Fig; Support for drain pipe

7.2.4 Typical arrangement for Support from roof/terrace of the building:



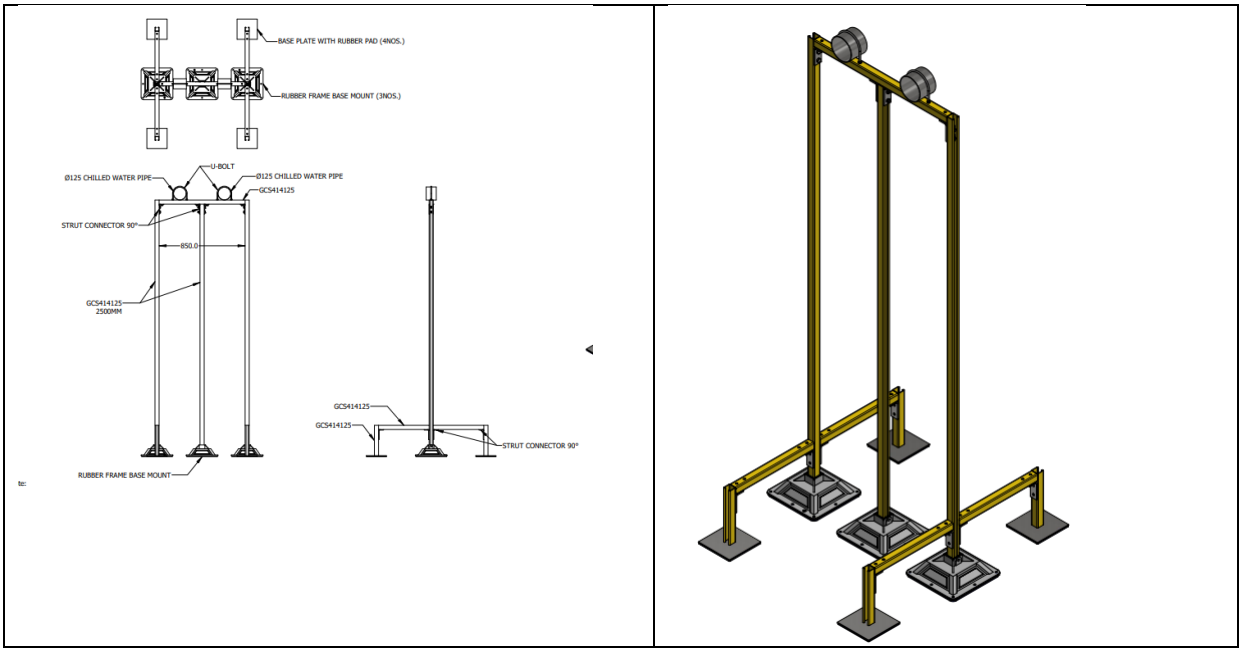


Fig: Support for CHW pipe

Note: Foot based supports should be used for terrace/floor application to avoid anchorage/drilling on terrace/floor.

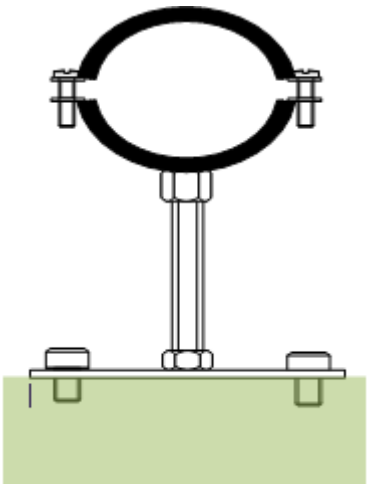


Fig: Support for Drain pipe

7.2.5 Typical arrangement for Support from wall:

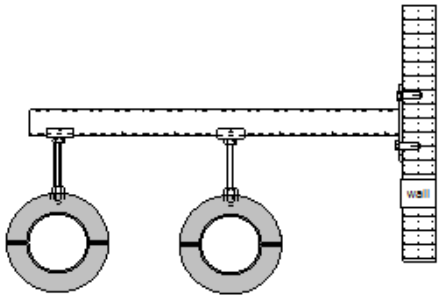


Fig: Arrangement for CHW pipe

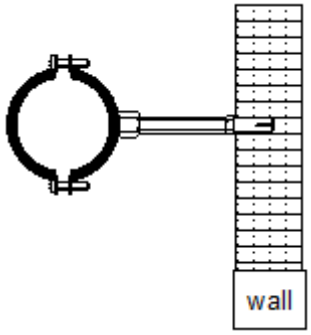


Fig: arrangement for Drain pipe

7.3 SEISMIC RESTRAINTS & SEISMIC VIBRATION ISOLATION FOR NON-STRUCTURAL COMPONENTS FOR MEP EQUIPMENT & DISTRIBUTION.

7.3.1 INTRODUCTION:

This specification is intended to provide general guidelines for the Seismic Analysis of Non-Structural components ie. MEP & FF distribution & equipments

7.3.2 SCOPE:

Seismic Analysis/Calculations should be carried out based on IS16700:2017. References from IS16700:2017 should be taken for seismic forces. Exceptions for Seismic supports as stated in ASCE7, SMACNA seismic restraint manual should be considered. For Fire-fighting distribution components & equipment sway bracing design and exceptions mentioned in NFPA 13 will supersede exceptions mentioned in ASCE 7.

7.3.3 DESIGN LOADS:

a. DEAD LOADS

The dead load is assessed based on the weight of the equipment/distribution system.

b. SUPERIMPOSED DEAD LOAD

The super imposed dead load is assessed based on the weight of the equipment / distribution system. For pipes containing water, weight of the water filled pipe is included in this load case.

c. EARTHQUAKE LOAD

Earthquake load should be calculated as per IS16700:2017, appropriate references from ASCE 7-10 should be considered considered

As per IS16700:2017/NBC 2016, following parameters should be considered

1. Seismic zone should as per NBC 2106 Part 6 Section 1 or as per building design seismic zone factor.
2. Seismic zone factor, Z – 0.24 (ZONE IV-Delhi NCR Region), as per NBC 2016 Part 6 Section 1 Table 42 Clause 5.3.4.2.
3. Seismic Design Force is calculated as IS16700:2017, as follows

Fp = Z * (1+x/h) (ap * Ip/Rp) Wp ≥ 0.10 Wp (As per IS16700:2017)

where,

Z = seismic zone factor given in NBC 2016 Table 42 (Clause 5.3.4.2) should be considered.

a.) Zone factor for some important towns are given at NBC 2016 Part 6 Section 1 Annexure K or as per building design seismic zone factor = 0.24 (Zone IV)

b.) Response Reduction Factor should be taken as per IS16700:2017.

c.) Amplification factor (as per IS16700:2017)

d.) Importance factor, Ip (as per IS16700:2017)

e.) z - Height in structure of point of attachment of component with respect to the base.

f.) h - Average roof height of structure with respect to the base

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

d. WIND LOAD ANALYSIS:

Calculate static and dynamic loading due to wind forces required to select/design vibration isolators, bases and seismic & wind restraints for outdoor & roof top equipments/services. The calculation of wind load shall be as per IS:875(Part 3)/NBC 2016 Part 6 Section 1. Worst case

between Seismic Loads and Wind Loads has to be considered for supporting and vibration isolation.

7.3.4 ANALYSIS METHOD

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

7.3.5 DESIGN METHODOLOGY

The supporting structural steel system shall be designed according to Limit state method as specified in IS: 800-2007. Appropriate loads and its combinations, as per relevant clauses in IS codes should be chosen for design. Based on selection location and type of seismic support for the same shall be provided in the shop drawings.

7.3.6 LOAD COMBINATION

The various loads are combined in accordance with the stipulations in NBC2016.
Load combinations considered in design are as follows:

Type	Load Case	Load Details
Primary	1	Dead Load-DL
Primary	2	Superimposed dead Load at Terrace- SIDL
Primary	3	Earthquake Load along X-Direction EQ(+X)
Primary	4	Earthquake Load along Z-Direction EQ(+Z)
Primary	5	Earthquake Load along Y-Direction EQ(+Y)

LOAD FACTOR FOR LOAD AND RESISTANCE FACTORED DESIGN (LRFD):

0.9 DL ± 1.5 (Eqx ± 0.3 Eqy) …… NBC2016 5.3.3.4

7.3.7 MATERIALS:

a. Structural Steel:

Materials	Standards
Hot-Rolled Members	
ISMC Channels	IS:2062
Angles	IS: 2062
Bolts & Nuts	Grade 4.6
Anchor fasteners	Grade 8.8
Cold-Formed Members	IS:811

b. Seismic Wire Rope Kit:

Wire based seismic restraint kits shall consist of Break strength certified, pre-stretched seismic cable with a permanently fixed 45 degree eyelet or ferruled copper/copper plated loop fixed to single, double or retrofit seismic bracket, or any other end fixture type or size as per manufacturers recommendation and design. The end fixing, bracket and wire must be of the same manufacturer. The system should be secured and tensioned with a Seismic rated self-locking grip at the other end. For ease of installation, flexibility, and workmanship only wire based seismic restraint system shall be used to restraint/brace all services.

Wire seismic restraints supplied and/or approved, shall be used with the system, the wire rope should not have color coding applied to it and should only be supplied with separate color coded tags. Bracing elements shall be seismic certified/tested by third party accredited lab as per ASHRAE standard 171, Method of Testing for Rating Seismic and Wind Restraints.

Cables shall have color coded size identifiers as per seismic requirements and must be pre-stretched. Cables shall be suspended 45 degrees (+/- 15 degrees Engineers allowances). Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and unlocking button should not be an integral part of the self-locking grip for safety purpose.

At the point of the seismic restraint installation, a rigid support is required (threaded rod + rod stiffener or appropriate as approved by a qualified engineer). The location of all the seismic restraint points shall be determined by a qualified engineer.

When attaching the seismic restraints to the slab/structure seismic rated anchor shall be used. The connection of channel/ stiffener to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

The seismic product to be used shall be determined by a qualified engineer, based on data supplied by the manufacturer.

The contractor shall select the seismic bracket for the attachment to the 'service' as either a standard or retrofit bracket. All parts and materials shall have been fully tested to conform to local/ state/provincial requirements and codes. The same manufacturer shall supply all parts and materials

The designer/contractor shall select the correct specification of wire based seismic restraints to use for restraining/bracing particular service mentioned in this specification; approved concrete anchors must be used by the designer/contractor. Refer to Table 1 below.

The Seismic engineer shall select the correct length of wire rope required to restrain/brace the various services & applications. No in–line joints should be made in the rope.

Table 1:

Wire based seismic restraint Safe Working Loads	
Kit Type	**Design Strength (LRFD) (kg)**
Type 2	239
Type 3	522
Type 4	1261

All Seismic restraints must comply with manufacturer's load ratings and recommended installation procedures.

c. Threaded Rod:

Size	Threaded Rod Diameter (mm)	Allowable Working Load (kN)	Allowable Working Load (kgs)	Max Unbraced Rod Length (mm) Table 7-5 ASHRAE Seismic Manual
M10	10	2.7	275.23	457
M12	12	5	509.68	635
M 16	16	8	815.5	584
M 20	20	12	1223.24	610
M 22	22	16.7	1702.34	660

d. Rod Stiffeners:

Rod stiffener consisting of steel channel and attachment clips capable of bracing vertical suspension rods or made out of Polypropylene to avoid potential buckling due to vertical compression forces should be used. Braces shall be selected to be of sufficient strength to prevent support rod buckling. Brace shall be attached to the vertical suspension rod by a series of attachment clips.

e. Riser Guides:

Risers shall be restrained against excessive lateral movement during service/earthquake. Riser guides must allow axial motion of the pipe and provide lateral restraint against static, hydrostatic & earthquake loads. The guides should include a neoprene bushing. This bushing allows some flexibility and prevents short-circuiting of vibration isolated device. The neoprene bushing also allows seismic loads to be cushioned and distributed to several guides.

f. Riser Anchors:

Straight solid risers can be rigidly anchored at one point provided the load is not concentrated on one floor. Riser anchors must be able to restraint against static, hydrostatic & earthquake loads. Riser anchor should restraint against excessive movement during services and earthquake thrusts by the use of 3-axis resilient anchors designed to withstand the required installation, operating and earthquake loads. Anchors shall be of steel construction and shall be attached to the riser with either a heavy-duty riser clamp or a welded support bracket in a manner consistent with anticipated design load. Snubbers shall limit lateral and vertical riser movements at each anchor location to a maximum of ¼" (6mm) in any direction. Anchors shall include a minimum of ½" (13mm) thick resilient neoprene pad to cushion any impact and avoid any potential metal-to-metal contact. Anchors shall be capable of withstanding an externally applied force of up to their rated capacity in any direction.

g. Riser Clamps

Riser clamps should be two-piece heavy-duty clamps bolted together and have a load rating based on clamping capacity. Riser clamps reinforce the pipe and distribute forces evenly to minimize pipe wall stress concentrations that would otherwise develop with welded lugs or brackets. The clamp must be sized for two times the dead load and there must be a positive means of engagement between the clamp and riser.

h. All Directional Seismic Restraint Spring Mounts

Spring isolators shall be single or multiple coil spring elements which have all of the characteristics of free-standing coil spring, incorporating lateral and vertically restrained seismic housing assemblies. Restraint housing shall be sized to meet or exceed the force requirements of the application and shall have the capability of accepting coil springs of various sizes, capacities, and deflections as required to meet the required isolation criteria. All spring forces shall be contained within the coil/housing assembly, and the restraint anchoring hardware shall not be exposed to spring generated forces under conditions of no seismic force. Spring element should have built-in levelling adjustment and shall be accessible from above and suitable for use with a conventional, pneumatic or electric impact wrench. Restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. Elastomeric elements shall be replaceable. Restraint shall allow ¼" (6 mm) free motion in any direction from the neutral position. Isolators should have a min. operating Kx/Ky ratio of 1.0, springs should have 50% additional travel to solid beyond rated load. Isolators should be selected in the range of -30% to +25% of rated load. All isolators certified to withstand minimum 1.0 G force. Seismic 'G' ratings for all seismic restraint products should be 3rd party certified and should be part of relevant submittal. Spring elements should be color-coded for easy field verification and should be capable handling high deflection and should have a low natural frequency.

i. Modular Support Components:

C-channel vertical suspension shall be selected to be of sufficient strength to prevent support buckling. Wire rope brace shall be attached to the connector connecting vertical suspension C-channel/threaded rod/stiffener with horizontal C-channel by a suitable connector capable of taking seismic loads. Stress analysis calculation should be submitted for the worst-case length of the C-Channel/Strut members used. Stress analysis should be done for tensile, compressive and combined stresses.

The connection of wire rope bracing /channel/ threaded rod to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

j. Flexible Connections/bellows for accommodation of differential seismic motion:

Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement. Install flexible connectors where adjacent sections or

branches are supported / connected by different structural/non-structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural/non-structural element from the one supporting the connections as they approach equipment. All installed bellows and flexible connections shall be designed to accommodate for seismic motion and deflection.

7.3.8 SERVICABILITY REQUIREMENTS:

a. Deflection:

Deflection Limitations shall be as per 5.6.1 Table 6 of IS800:2007

7.3.9 Seismic bracing Design:

Seismic Supporting system shall be analyzed for seismic forces as per IS 16700 Cl. 10.2 and design intent of SMACNA seismic restraint manual - Guidelines for Mechanical system; ASCE 7-10 Chapter 13 and ASHRAE Practical Guide to Seismic Restraint shall be used as a reference for design basis & exceptions. The load calculations, stress calculations, design basis and exceptions considered shall be part of submittal for approval.

a. Project Design Criteria:

To be mentioned in the submittal documents:

Description	Standard
Seismic Zone	IS16700:2017
Seismic Zone factor	NBC 2016 Table 42 (Clause 5.3.4.2) or as per building seismic zone factor.
Soil Site class	as per site location
Importance Factor (Ip)	IS16700:2017
Component amplication factor (ap)	IS16700:2017
Component response modification factor (Rp)	IS16700:2017
Component response modification factor (Rp) for base isolation	IS16700:2017
Height in structure of point of attachment of component with respect to the base (z)	As per level of attachment of component
Average roof height of structure with respect to the base (h)	As per level of attachment at the roof/slab/peb level
z/h	ratio based on above parameters

For Calculations:

Description	Formula & Values
Seismic Design force In horizontal direction (Fp')	to be part of submittal
Vertical seismic force (Eqy')	to be part of submittal

Maximum Distance between Bracing for Pipes:

Steel and Copper Pipe with Welded, Brazed, Grooved, or Screwed Connections

Maximum Seismic Acceleration Input (g)	Maximum Transverse Brace Spacing ft (m)	Maximum Longitudinal Brace Spacing. ft (m)
0.25	50 (15.2)	80(24.4)
0.50	40(12.2)	80(24.4)
1.0	40(12.2)	80 (24.4)
2.0	20 (6.1)	40 (12 2)

PVC or PVDF Pipe with Solvent-Welded Connections

Maximum Seismic Acceleration Input (g)	Maximum Transverse Brace Spacing, ft (m)	Maximum Longitudinal Brace Spacing, ft (m)
0.25	25 (7.6)	40 (12.2)
0.50	20(6.1)	40(12.2)

1.0	20(6.1)	40 (12.2)
2.0	10(3.0)	20(6.1)

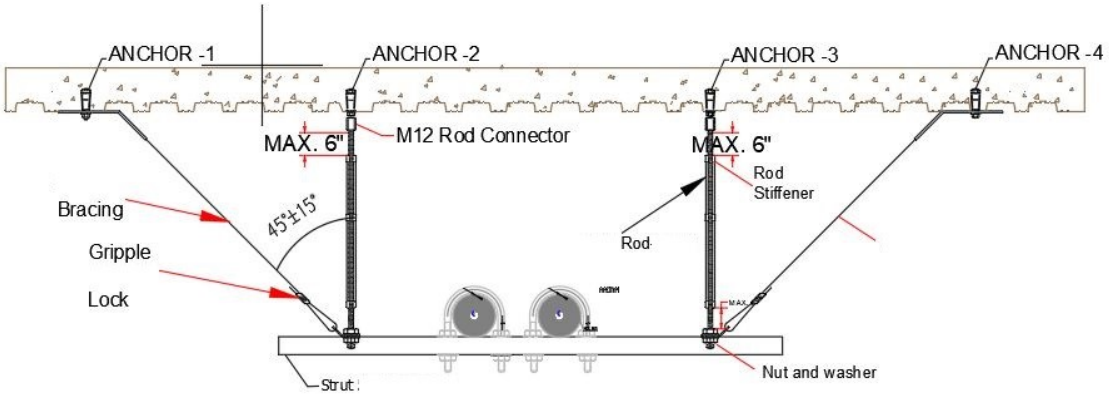
No-Hub Pipe with Shield and Clamp Connections

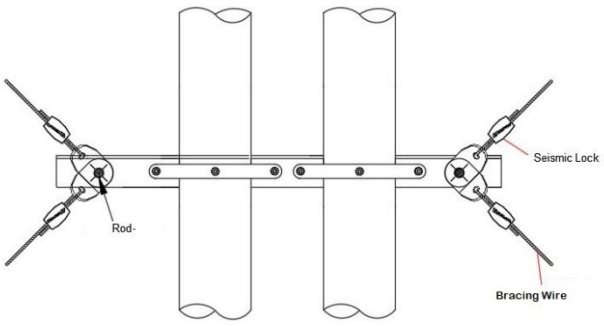
Maximum Seismic Acceleration Input (g)	Maximum Transverse Brace Spacing. ft (m)	Maximum Longitudinal Brace Spacing ft. (m)
0.25	25(7.6)	40(12.2)
0.50	20 (6.1)	40(12.2)
1.0	20(6.1)	40 (12.2)
2.0	10(3.0)	20(6.1)

Maximum Distance between Bracing for Ducts:

Maximum Seismic Acceleration Input (g)	Maximum Transverse Brace Spacing. ft. (m)	Maximum Longitudinal Brace Spacing, ft. (m)
0.15	40 (12.2)	80 (24.4)
0.50	30(9.1)	60 (18.2)
1.0	30 (9.1)	60 (182)
2.0	20(6.1)	40 (12.2)

Typical arrangement for Seismic supports for Piping:





NOTE: PIPING SUPPORTING SYSTEM TO BE DESIGNED BY A COMPETENT AGENCY TO ENSURE SAFETY OF THE INSTALLATION, BUILDING AND THE PERSONS. CONTRACTOR TO HIRE A SPECIALISED

AGENCY FOR DESIGN AND INSTALLATION OF THE PIPING SUPPORT SYSTEM AND ASSUME COMPLETE RESPONSIBILTY ON ADEQUACY OF THE SUPPORT SYSTEM. CONTRACTOR TO SUBMIT A CERTICATE FROM THE STRUCTUAL CONSULTANT ALONG WITH THE DESIGN AND DRAWINGS SUBMITTED TO THE CLIENT/PMC.

8. PRE-INSULATED PIPES

Pre insulated pipes, as called for in schedule of quantities shall be sourced from the factory in length of minimum 6m. Metered dose of Polyurethane foam shall be injected in annular space between pipe OD and outer jacket to achieve average density of 36 Kg/m^3. After expanding, homogenous foam shall be formed between the cavity with no air gaps. Suitability of temperature range shall be from (-) 20^0C to 120^0 C.

Outer jacket shall be of GI / HDPE as indicated in schedule of quantities.

9. PRESSURE GAGES AND THERMOMETERS

Burden type pressure gauges of 100mm dia of suitable range shall be provided at the following locations:

a) Chiller / Condenser / Cooling coils of AHU - Inlets and outlets.
b) All pumps - Suction & discharge

The water pressure gauge shall be made of stainless steel grade SS304. The dial plate shall be powder coated with white colour base & the calibration shall be done in black colour. All the pressure gauges shall be complete with ball valves & SS Siphon and confirming to IS:3624. Gauge shall be connected to the pipes by 6mm diameter SS syphon tube through a ball valve.

9.1 THERMOMETER

Direct reading V form type or dial type 100mm thermometer alcohol filled of suitable range / length shall be provided at the following locations:

a) Condenser / Chiller / Cooling coil – Inlets and outlets in separate wells of Brass / Gun metal.

The V form thermometer shall be made of aluminium die casting with golden colour anodizing. The thermometer shall have a V groove in the body to protect the refill from the damages during the installation. The refill shall be filled with blue colour mercury. The thermometer shall be complete with brass well & the calibration of temperature shall be in Celsius & Fahrenheit. Thermometers shall be suitable for 15mm connections. Thermometers shall be suitable for 15mm connections. Thermometer for chilled water pipes shall be of long stem, so that it is removable without damaging insulation.

9.2 AIR-VENTS

Air vents for purging of air trapped in piping system shall be provided at the highest point. Globe valves of the size as indicated below shall be provided & no additional price shall be paid.

10. TESTING

a. During construction, the contractor shall properly cap all lines, so as to prevent the entrance of sand, dirt, etc. Each system of piping shall be flushed thoroughly after completion (for the purpose of removing dirt, grit, sand etc. from the piping and fittings) for as long a time as is required to thoroughly clean the system.

b. All piping shall be tested to hydrostatic test pressure of atleast two times the maximum operating pressure, but not less than 10 kg per sq. cm gauge for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified, retested and gotten approved

c. Piping repaired subsequent to the above pressure test shall be re-tested in the same manner.

d. Piping may be tested in sections and such sections shall be securely capped, then re-tested for the entire system.

e. The Contractor shall give sufficient notice to all other agencies at site, of his intention to test a section or sections of piping and all testing shall be witnessed and recorded by Owner's site representative.

f. The contractors shall provide temporary pipe connections to initially by-pass condenser/chiller and circulate water through condenser/chilled water pipe lines for minimum 8 hours. Water should be drained out from the lowest point. The temporary lines shall be removed and blanked with dead flanges. Pot strainers and Y strainers shall be cleaned and fresh water filled in the circuits.

g. The Contractor shall make sure that proper noiseless circulation of fluid is achieved through all coils and other heat exchange equipment in the system concerned. If proper circulation is not achieved due to air bound connection, the Contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and re-finishing of floors and walls if required.

h. After the piping has been installed, tested and run for atleast three days of eight hours each, all insulated exposed piping in plant room shall be given two finish coats, 3 mils each of approved colour, conforming to relevant BIS Codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows. For painting of insulated and clad pipes refer to Insulation section.

i. After testing, all systems shall be chemically cleaned. After cleaning, the pipe work should be rinsed multiples times until the system is neutral.

Before handover Owner's site representative shall be provided with certificate of cleaning of pipe systems, signed by the contractor.

j. The Contractor shall provide all materials, tools, equipment, instruments, services and labour required to perform the test and to remove water resulting from cleaning and after testing.

11. BALANCING

a. After completion of the installation, all water system shall be adjusted and balanced to deliver the water quantities as specified, quoted, or as directed.

b. All balancing valves, Automatic control valves and two-way diverting valves shall be set for full flow condition during balancing procedure. Each water circuit shall be adjusted thru balancing valves provided for this purpose; these shall be permanently marked after balancing is completed, so that they can be restored to their correct positions, if disturbed.

c. Complete certified balancing report shall be submitted for evaluation and approval by Owner's site representative. Upon approval, four copies of the balancing report shall be submitted with the as-installed drawings and completion documents.

12. VALVE IDENTIFICATION

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

The contractor shall frame under glass in the air conditioning plant room or as directed by Owner's site representative two copies of valve chart. Two additional unmounted copies shall be supplied to the Owner's site representative.

Tags shall correspond with the valve schedule and record drawings. In back of house areas, where

ceilings are installed and the valve or valve tag is not visible, a self adhering tag with the valve number shall be installed on the wall or directly under the ceiling. For public area ceiling valves, these tags are to be installed in the service corridor, leading to the public areas.

13. MEASUREMENT FOR PIPING

Unless specified otherwise, measurement for piping for the project shall be on the basis of centre line measurements described herewith.

Piping shall be measured in units of length along the centre line of installed pipes including all pipe fittings, flanges (with gaskets, nuts, and bolts for jointing), unions, bends, elbows, tees, concentric and / or eccentric reducers, inspection pieces, expansion loops etc. The above accessories shall be measured as part of piping length along the centre line of installed pipes, and no special multiples of pipe lengths for accessories shall be permitted.

The quoted rates for centre line linear measurements of piping shall include all wastage allowances, pipe supports including hangers, MS channel, PUF supports, nuts, check nuts, vibration isolator suspension where specified or required, and any other item required to complete the piping installation as per the Specifications. None of these items will be separately measured nor paid for.

However, all valves (gate/ globe / check / balancing / purge / butterfly / drain etc), strainers, thermometers, pressure gages shall be separately counted and paid as per their individual unit rates, which shall also include their insulation as per Specifications. Piping measurements shall be taken before application of the insulation.

Contractor shall get pressure testing of pipes/measurements etc verified by the Owners representative at site.

SUBHEAD-J. COOLING TOWERS

1. SCOPE

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

2. TYPE, CAPACITY & QUALITY

- Cooling Towers shall be induced draft /forced draft in accordance with requirement of Drawings and of the Schedule of Quantities.
- Cooling Tower capacity shall be selected on the basis of monsoon time Ambient wet bulb temperature or the worst case Ambient wet bulb temperature , whichever is higher i.e the highest Ambient wet bulb temperature of the site/location.
- Cooling tower shall be CTI certified & CTI marked.
- Provide Cooling Technology Institute (CTI) certification of tower cooling capacity, based on performance tests, in accordance with CTI Standard 201. Heat rejection performance as per ASHRAE 90.1 latest edition.
- Provide written manufacturer guarantee that the tower will perform in complete compliance with performance requirements, provided the tower is installed in accordance with the manufacturer's written instructions. This guarantee shall include the manufacturer providing in-situ testing of the tower performance in accordance with CTI Standard ATC- 105, by a testing agency licensed by CTI, if required by the designer or owner.
- Noise Level: Noise level @ distance of 3 meter from the cooling tower shall not be more than 72 to 75 dbA without the use of sound deflection cowls.
- Motor efficiency: Motor efficiency shall be IE2/IE3/IE4 as specified in the schedule of quantities. Motors shall be TEFC, IP55 rated & Class F Insulation.
- Motor shall be suitable for VFD application i.e. to work at low frequency & low voltage without causing noise & heating.
- Cooling towers shall be of low approach. (5 deg F to 7 deg F, as specified in the schedule of quantities).

3. INDUCED DRAFT COOLING TOWER

Cooling Towers shall be suitable for outdoor use. Tower shall be vertical, induced draft, counter / cross flow type. FRP construction, in rectangular/ square /octagonal profile, complete with fan, motor, diffusion deck spray section, eliminators, steel supports, and sound attenuation / sound deflection cowl equipment where called for in Schedule of Quantities. Cooling tower may be single / multiple cells in accordance with the requirement of drawings & schedule of quantities.

a. Capacity

The cooling tower capacities shall be as per the Drawings and Schedule of Quantities.

b. Side Casing

This shall be made out of FRP construction of minimum 5 mm thick and UV stabilized with smooth surface on both sides for minimum resistance to air flow. It shall have sufficient structural strength to adequately withstand high wind velocities and vibration. The casing may be installed in the reinforced cement concrete basin if so identified in drawings, or in Schedule of Quantities. The tower supporting structure shall be made out of hot dipped galvanized tubular frame. Air intake shall be all along the sides so that tower can be installed quite independent of prevailing wind direction. Anodized aluminium or PVC louvers integrated with fill UV stabilized PVC fill and backed up by galvanized bird screen / FRP Louvers shall be provided at air intake. Sufficient clearance between casing and adjoining structures shall be provided to enable servicing and periodic cleaning.

c. Cold Water Basin

Cold water basin shall be a deep sump and made out of 5 mm thick FRP construction, single piece and UV stabilized on which cooling tower super structure shall be supported. RCC suction tank with easily removable double brass strainers may be provided with this basin, if separately identified in drawings or

in Schedule of Quantities.

Each Basin's fittings shall include the following:

i. Bottom outlet.
ii. Screened suction assembly fixed to the casing.
iii. Drain connected to the side / underside of basin, with a valve.
iv. Overflow connected to the side of basin.
v. Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
vi. Brass Ball type automatic make up float water valve.
vii. Quickfill connected to the side of basin.
viii. Equalizing connection and balancing valve for multiple cooling towers / multiple cells.

d. Distribution System

Hot water distribution system shall comprise of header and branch arms system with HDPE nozzle flow system. Provide the nozzles to ensure even distribution of water over wetted-surface-fill. The spray header and branches shall be constructed of Heavy duty, polyvinyl chloride pipe for corrosion resistance and shall have a steel connection to attach the external piping. The piping shall be removable for cleaning purposes. The water shall be distributed over the fill by HDPE spray nozzles with large orifice openings to eliminate clogging.

e. Filling

Fillings shall be made of corrosion proof and rigid PVC film in honey comb design and arranged in square/rectangular form. Fill sheets shall be suspended from hot dip galvanised steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent fouling through scales that may form.

f. Drift Eliminators

In order to reduce carry-over losses through entrapment of moisture drops in air stream, virgin PVC or CPVC plastic drift eliminator shall be installed which is fabricated into configuration to limit drift loss to a maximum of 0.005% of the condenser water flow-rate. Drift eliminators may be integral with the fill. The eliminator design shall incorporate two changes in air direction to assure complete removal of all entrained moisture from the discharge air stream.

g. Fan & Other Mechanical Equipment

Fan shall be of the propeller type cast AL alloy, light-weight rotor fitted with multiple aerofoil blades. The entire fan assembly shall be made of Aluminum casting, statically and dynamically balanced. Fan shall be directly / spiral bevel type gear-reducer driven / V-belt driven by 415 ± 10% volts, 3 phase, 50 cycles, AC supply, TEFC, IP55, motor of approved make, totally-enclosed, fan-cooled, weather- proof construction, designed and selected to operate in humid air stream. Fan shall be protected by fan guard and bird screen of galvanized steel construction & shall be easily accessible for inspection and maintenance. An Aluminum service ladder for each cell of the cooling tower shall also be provided to reach up to the top of cooling tower for greater convenience. Provide ladder safety cage also . The mechanical equipment assembly shall be adequately supported on a rugged steel base welded to tubular support assuring vibration-free support. G.S.S / FRP canopy shall be provided over the fan motor for protection against rain water. Care shall be taken that fan air is not restricted. Motor terminal box shall be made water tight. Provide fan motor disconnect switch in weather proof IP 65 enclosure rigidly attached to the cooling tower.

Motor shall be suitable for VFD application, with better quality of motor winding insulation so as not get heated up and does not cause noise when running at low frequency and lower voltages. Motor shall be IE2/IE3/IE4 energy efficient as asked for in the schedule of quantities. Motors shall be TEFC, IP55 rated & Class F Insulation.

h. Painting

The exterior steel surfaces of all towers shall be given two coats of paint of approved finish. If these shop

coats become marred during shipment or erection, the affected areas shall be cleaned off with mineral spirits, wire brushed and spot primed then coated with enamel paints of matching shades. FRP towers shall be provided of color approved by Architect.

i. Hardware

All hardware used in cooling tower shall be of stainless steel.

j. Installation

Cooling tower shall be installed on the ground / roof top as called for in the drawings. Steel frame as per OEM of cooling tower shall be epoxy-coated to prevent corrosion.

Concrete flooring shall be provided for this area with proper drainage system.

k. Vibration Isolators

These shall be provided and installed at specific points of the tower base to isolate vibrations generated from tower. Necessary vibration isolation pads along with necessary foundation nut & bolts to be provided along with the cooling tower.

l. Cooling Towers Efficiency: As per Table 5.18 of ECBC-2017

m. Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

4. FORCED DRAFT COOLING TOWER

Forced draft cooling tower shall be FRP construction of minimum 5 mm thick and UV stabilized and structural framed, counter-flow forced draft type, suitable for outdoor use. Tower shall be complete with fan, motor, diffusion deck, spray section and eliminator plate. Tower shall be selected for low height and lowest possible noise level as defined in Schedule of Quantities.

a. Capacity

The cooling tower capacity shall be as per the Drawings and Schedule of Quantities.

b. Casing

Casing and basin shall be of FRP of minimum 5 mm thick respectively and sealed for water tightness. All joints and corners shall be sealed and an aluminium ladder with safety cage shall be provided to reach upto the top of cooling tower's each cell.

c. Cold Water Basin

Cold water basin shall be a with deep sump single piece 5mm thick FRP construction, in which cooling tower superstructure shall be supported. Easily removable brass-strainers shall be provided with the basin and pump suction shall be provided after strainers.
Each Basin's fittings shall include the following:

i. Side outlet.
ii. Screened suction assembly fixed to the casing.
iii. Drain connected to the side / underside of basin, with a valve.
iv. Overflow connected to the side of basin.
v. Built-in bleed off attached to inlet header discharging through polyethylene tube into overflow pipe.
vi. Brass Ball type automatic make up float water valve.

vii. Quickfill connected to the side of basin.
viii. Equalizing connection/balancing valve for multiple cooling towers / multiple cells.
ix. Bird screen at air inlet/outlet of the fan.

d. Distribution System

Hot water distribution system shall be comprising of header and branch arm system or open pan gravity flow system suitable for high pressure.

e. Filling

Fillings shall be made of corrosion proof and rigid UV stabilized PVC film in honey comb / modular design and arranged in square / rectangular form. Fill sheets shall be suspended from H.D.G steel structural tubing supported from the lower structure & shall be elevated above the floor of the cold water basin to facilitate cleaning and easy replacement. They shall be arranged in such a manner to ensure negligible resistance to air flow and to eliminate back water spots and prevent fouling through scales that may form. In order to reduce carry-over losses through entrainment of moisture drops in air stream, PVC drift eliminator shall be installed.

f. Fan & Other Mechanical Equipment

Fan shall be centrifugal/axial fan, aluminium alloy aerofoil construction. The entire fan assembly shall be statically and dynamically balanced. Fan motor shall be low RPM, suitable for 415±10% volts, 3 phase, 50 cycles AC supply, energy efficient motor IE2/IE3/IE4 as asked for in the schedule of quantities type electric motor, IP66, TEFC, Class F Insulation, weather-proof construction. The mechanical equipment assembly shall be adequately supported through galvanized steel angle frame work. The hot and humid air shall be discharged at the top level. Galvanized steel construction bird screen at outlet shall be provided to prevent birds from nesting during idling period. Motor shall be suitable for VFD application i.e., with better winding insulation to withstand any temperature rises at low speed.

g. Painting

The exterior steel surfaces of all towers shall be given two coats of paint of approved finish. If these shop coats become marred during shipment or erection, the affected areas shall be cleaned off with mineral spirits, wire brushed and spot primed then coated with enamel paints of matching shades. FRP towers shall be provided of color approved by Architect.

h. Hardware

All hardware used in cooling tower shall be of stainless steel.

i. Installation

Cooling tower shall be installed on the ground / roof top as called for in the drawings. Steel frame as per OEM of cooling tower shall be epoxy-coated to prevent corrosion.

Concrete flooring shall be provided for this area with proper drainage system.

j. Vibration Isolators

These shall be provided and installed at specific points of the tower base to isolate vibrations generated from tower

k. Cooling Towers Efficiency: As per Table 5.18 of ECBC-2017

l. Motors Efficiency shall be as per ECBC-2017: (As specified in schedule of quantities)

ECBC	IE2
ECBC +	IE3
Super ECBC	IE4

5. PERFORMANCE DATA

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

6. TESTING

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

b. Manufacturer shall Provide Cooling Technology Institute (CTI) certification of cooling tower cooling capacity, at tender design conditions (entering & leaving condenser water temperature, entering air wet bulb temperature, water flow rate, fan KW) also provide certificate that the cooling tower, accessories and components withstand the seismic force as per zone defined by NBC of India.

SUBHEAD-K. Dynamic Pressurization unit, Expansion tank with built in De-aerator & Top up

- Expansion, Pressurization, deaeration and Top up of the chilled water system to be provided by an integrated unit comprising of Pressure-less expansion tank with coalescing pall rings, Dynamic Pressurization unit with integrated automatic water make-up connection complete with state of the art digital controller.
- The pressurization unit shall be sized appropriate to the total system expansion volume and maximum operating pressure. The units shall be Manufactured and designed in accordance with European Pressure Equipment Directive PED 2014/68/EC.
- The units shall be Manufactured and designed in accordance with European Pressure Equipment Directive PED 2014/68/EC.The controller shall regulate the pump unit to operate as Cyclic duty - standby/assist with automatic changeover.
- System pressure shall be regulated within ± 0.2 bar (2.9 psi) of the set pressure. High- and Low-pressure alarm setting shall be selectable by the user.
- The pressurization unit shall have non-return valve, flow restrictor valve and solenoid valve as well as a safety relief valve for the vessel and a "Y" strainer for safe operation. Solenoid Valves to be used to avoid Pressure Surges, i.e. unit shall not incorporate electrically actuated ball valve in the spill line since it takes time to react and increases pressure peaks which otherwise would lead to malfunctioning of the system.
- Top-up function shall be programmed according to system requirements. The unit shall have flood limiter algorithm to shut down the system in the event of a serious leak. Water level in the expansion vessel(s) shall be maintained to a minimum value.The unit shall have provision of NFE 1.2 fillset with impulse output water meter with volt free pulse output, consisting of backflow preventer, water meter, ball valve & non return valve.The system pressure to be monitored by a touchscreen microprocessor controller. The control unit shall read the system pressure via a pressure transducer and shall maintain the pressure within the close tolerance limit of +/- 0.2 bar.

- The degassing of a partial flow of the installation water shall be processed according to an optimized time schedule with selected table degassing programmes in the controller. After a period of continuous degassing (adjustable and depending on the installation volume) at the start up, the controller shall switch automatically to an interval degassing mode.
- The system shall be able to offer following Communications/Connectivity :
    - USB port for saving the operational log or performing a Firmware update.
    - Ethernet port to connect the unit to a Building Management System (BMS) via Modbus or Bacnet,
    - RS-485,
    - BMS via Modbus or via Bacnet.
    - Wireless Communication optional to connect and perform seamless commissioning even remotely through same Organization's smartphone application.
    - Canbus ports or the interconnection of multiple Pressurization units.
    - In case of two or more dynamic pressurization units : The units shall incorporate Co-Operation mode where Slave can automatically take over in the event of the Master failing or functioning poorly ('Floating Master') without interrupting the pressure maintenance of the CHW system

- The system shall has optional offering for Monitoring, Alarm and Diagnostic Capabilities :
    - The unit shall have provision of subscription to Remote Service to create insights into the use of the installations & maintenance. The remote service platform shall enable remote service, alerting and notifications and contain all devices info and history. Remote Service portal shall enable you to perform analyses, optimize the system, and execute preventive maintenance.
    - The system can be remotely monitor and access the units for Health Check, Commissioning and provide immediate notification when an installation or product has a malfunction. The gateway shall have a serial connection to connect to the device and use highly secured cellular technology for connecting to the remote service cloud platform.
    - Analog voltage output signals for remote indication of vessel level and system pressure (0-10V).
    - Event logging: Alarm activations, Pump Run counter (activations per pump), Cumulative run timer (hours per pump), Electrical interruption.
    - Controller shall display fault code and generate the alarm in case of any fault situation.

- The pressure-less expansion vessel(s) shall be cylindrical, welded and comply to EN 13831:2007/AD2000, Manufactured and designed in accordance with European Pressure Equipment Directive PED 2014/68/EC.
- A high capacity brass automatic air vent shall be installed on the top of the vessel. The 'Turbo-vent' function shall release the Air via an automatic air vent installed on the top of the vessel
- Vessel volume shall be calculated according to the system expansion volume. Every vessel in the unit shall have the same size. Levelling of the vessel shall be facilitated by adjustable feet. Condensate drain cock shall be installed within the base of the vessel.
- Efficiency of the vessel volume shall be minimum 80%, For De-aeration Integrated micro bubble separator with PALL rings shall be an integral component of pressurization unit and be installed within the inlet of the expansion vessel providing removal of micro-bubbles down to value 18µm.
- The expansion vessel(s) shall be fitted with a replaceable butyl rubber bladder with rupture sensor in accordance with DIN 4807-3. As unit is subject to atmospheric pressure, tank pressure rating should be 3 Bar. Maximum continual working temperature of the bladder shall be 70 °C (158 °F).
- Main vessel must have a Weight sensor to provide vessel content information in percentage.
- Main vessel must be connected to the Pressurization unit using flexible hoses.
- The use of secondary pressurized expansion tank is not accepted.
- Expansion Tank shall have third party certificate (TUV / lloyds registered).
- The controller shall display the vessel contents, system pressure and status of the main operating components in real-time on the graphical display. This acts as confirmation that pump(s) or valves are operating and responding as required, while also verifying the system setup.
- Pressurization unit shall to be factory assembled, with Factory conforming to ISO 14001:2015 and BREEAM. The product shall be installed according to the manufacturer's instructions using manufacturer's approved components.
- Manufacturer's Authorized representative shall submit their Pre-commissioning and Commissioning Report Format during Order Finalization with agreed Set Parameters

EXPANSION TANK PRESSURIZATION UNIT WITH VACUUM DEGASSER

- Expansion, pressurization and Vacuum Degassing of the chilled water system to be provided by an integrated unit comprises of pressurized expansion tank, pressurization unit with stainless steel cylinder for effectively removing of dissolved gas by vacuum degassing function c/w state of the art digital controller, break tank all inside a compact cabinet.
- The Expansion tank & pressurization unit shall be sized appropriate to the static height above the expansion tank (meters), total system volume, maximum ambient temperature, maximum allowable system pressure and safety relief valve settings and glycol content (%) if required.
- The expansion tank shall be fitted with a replaceable high quality butyl rubber bladder/EPDM in accordance with DIN 4807-3, Nitrogen gas filling for longer maintenance of pre-pressure.
- The pressurized expansion tank shall be cylindrical, In accordance with Pressure Equipment Directive 2014/68/EU. Tanks from (100 - 1000 liters): in accordance with EN13831 and from 1200 - 8000 liters: in accordance with AD2000.
- Pressurization unit shall be manufactured and designed in accordance with European Pressure Equipment Directive PED 2014/68/EC and Machinery Directive 95/16/EC.
- Expansion Tank shall have third party certificate (TUV / lloyds register).
- The expansion tank shall have Red (RAL 3002) epoxy powder coating.
- Tank shall be Suitable for addition of glycol-based anti-freeze up to 50%.
- Tank shall be delivered with pressure gauge.
- System pressure shall be regulated within ± 0.2 bar (2.9 psi) of the set pressure. High and low-pressure alarm setting shall be selectable by the user.
- Maximum continual working temperature of the bladder shall be 70 °C (158 °F), and tank shall be Suitable for systems with a flow temperature of 120 °C.
- The Pressurization unit shall have two pumps (Working+Standby) / duty standby housed in a steel cabinet with vacuum degassing cylinder of Stainless steel for removal of dissolved gas c/w WRAS Approved Polypropylene break tank, WRAS approved float valve, over flow connection, pressure sensor, solenoid valve, isolation Valve, NRV, Drain Valve.
- The system shall have controller for pressurization as well as vacuum degassing function. The controller shall be IP54 rated, with bright LED display scrolling messages including pump operation and alarm mode, digital pressure setpoint with adjustable differential, and security password protection, High and low pressure alarm setting shall be selectable by the user. The Vacuum degassing function and pressurization function shall be programmable according to system requirement,
- Pressure setting should be in 0.1 bar increments.
- In case of any fault, controller shall display the fault code and generate the alarm
- Auto resetting low water detection.
- The unit shall be with MODBUS RTU Communication protocol.
- The unit shall be with Pump pulse option, Flood Protection (Pump Runtime Limiter, Excessive Start Alarm). Event logging: Alarm activations, Pump Run counter (activations per pump), Cumulative run timer (hours per pump), Electrical interruption.
- Volt free contacts should be available for Common Alarm, High Pressure Alarm, Low

Pressure Alarm, Sensor Health, Pump 1 Health, Pump 2 Health .

- Factory should be conforming to ISO 14001:2015 and BREEAM. The product shall be installed according to the manufacturer's instructions using manufacturer's/distributors approved components.

SUBHEAD-L. Air and Dirt Separator

- For constant, highly efficient in-line removal of free air, bubbles and microbubbles in combination with separation and removal of dirt particles within chilled and hot water systems.
- Air and Dirt Separator shall be sized appropriate to the maximum operating pressure and flow velocity of the system.
- Manufactured and designed in accordance with European Pressure Equipment Directive PED 97/23/EC. Cylindrical vessel shall be manufactured from welded steel. Material shall be EN/ISO: S235JR+N
- The acceptable design shall incorporate a separating element to force water into tranquillity zones for air and dirt removal. A nozzle shall force de-aerated water into the main flow to divert contaminated water through the separating element. A high capacity, conical brass automatic air vent shall be installed on the top of the vessel for air discharge. Heavier than water dirt particles shall be removed via a blow down valve on the base of the vessel. The use of tube mesh and wire mesh made of copper or any metal is not permitted for separation purpose, wire mesh/tube increases the pressure drop and maintenance requirement.
- Ferrous particles down to 4 µm shall be captured by a magnetic device in the lower part of the vessel. The magnet shall be retractable to enable ferrous particles to be released and discharged through the drain valve which will incorporate an internal scraper to dislodge particles that adhere to the inner surface of the vessel base.
- Floating debris and scum shall be removed via a high level drain valve.
- Inlet and outlet of the unit shall be via horizontally-opposed,
- Coaxial flanged connections in accordance with EN 1092-1 PN 16/25.
- Finish shall be epoxy powder coating.
- The maximum permissible flow velocity shall be 3 m/s.
- System operating temperature shall be within the range of -10 °C to 120 °C.
- Glycol mixture up to a maximum ratio of 50 % shall be permissible.
- The acceptable design shall require minimal maintenance and not require the vessel to be taken out of commission, de-pressurized or drained for routine blow down and cleaning. It shall be of a direct flow-through design and flow shall not be impeded by the use of any coalescing media to ensure that pressure drop is negligible.
- It shall be able to provide up to 40% separation per cycle. It shall be able to remove at least 15% of 70 µm microbubbles per cycle and at least 35% of 150 µm dirt particles per cycle.
- Air and Dirt Separator shall be factory assembled. The product shall be installed according to the manufacturer's instructions using manufacturer's approved components.

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SUBHEAD-M. Side Stream Filtration systems

PART I – GENERAL

1.01 Summary

Furnish and install the liquid-solids separation system as specified herein.

A. Primary Purpose – The system will remove unwanted solids from a cooling tower sump or remote basin or condenser line using a centrifugal-action vortex separator. The liquid-solids separation system will help prevent particle fouling of the cooling system's components reduce maintenance and servicing routines, maintain optimum energy efficiency of the heat exchange process, limit blow down & chemical use practices and control harmful bacteria growth in the basin/sump/condenser loop. Fluid viscosity must be 100 SSU or less.

B. For Side Stream Installations -- Control of solids in the re circulated cooling water system shall be accomplished via a side-stream flow of 10-25 % of the full-stream system flow through a completely assembled separation/filtration package. The package's pump shall provide sufficient pressure for the re-introduction of side-stream fluid back into system flow.

1.02 System Performance Requirements

Testing Requirements – Each separator must be subjected to Pneumatic leak testing by the manufacturer prior to shipment.

Independent Testing Laboratory – Performance Testing must be done by an independent and identified testing laboratory for any of the separator. Standard test protocol of upstream injection, downstream capture, and separator purge recovery is allowed with 50-200 mesh particles to enable effective, repeatable results. Single pass test performance must not be less than 95% removal.

PART II – PRODUCTS

2.01 Performance

Flow Capacity -- Unit shall have a flow capacity of ……. US GPM or ……. m^3/hr
Pressure Loss – Shall be between 3-12 psi (.2 to .8 bar) remaining constant, varying only when the flow rate changes with mentioned range.

A. Solids Removal Effectiveness

All Systems – In a single pass through the separator, given solids with a specific gravity of 2.6 and water at 1.0, performance is expected to be 98% of 74 microns and larger.

In Recirculating Systems -- 98% performance is predictable to as fine as 40 microns (given solids with a specific gravity of 2.6).

B. Maximum working pressure: 150 psi (10.3 bar).
Maximum operating temperature: 140º F (60º C).

2.02 Construction

A. **The separator package** -- Shall provide for initial pre-straining prior to pump suction (except for side-stream applications), followed by direct pumping through a specific centrifugal-action solids-from-liquid separator. Separated solids shall be continuously bled from the separator's collection chamber into the package's integral solids recovery vessel and solids collection bag. Excess liquid shall pass through the bag and return to system flow via piping connected to the package's pump suction line. Alternatively, the separated solids may be purged periodically to desired disposal with an automatic purge valve.

B. **Pump** -- End-suction, single stage; TEFC motor; iron / Bronze impeller; flooded suction required.

C. **Lakos Separator** -- Centrifugal-action accessible design, incorporating a true tangential inlet and mutually tangential Swirlex internal accelerating slots, employed to promote the proper velocity necessary for the removal of the separable solids. The internal accelerating slots shall be spiral-cut for optimum flow transfer, laminar action and particle influence into the separation barrel. Avoid Dome type or Dumbbell type of Separator construction to prevent the lack of internal method of acceleration. The separator's internal vortex shall allow this process to occur without wear to the accelerating slots. Separated particle matter shall spiral downward along the perimeter of the inner separation barrel, in a manner which does not promote wear of the separation barrel, and into the solids collection chamber, located below the vortex deflector plate. The separator shall be of unishell construction with SA-36, SA-53B or equivalent quality carbon steel, minimum thickness of .25 inches (6.35 mm).Supplier must submit the cross section view of their product to substantiate above design.

D. **Vortube** -- To ensure maximum particle removal characteristics, the separator shall incorporate a vortex-induced pressure relief line (Vortube), drawing specific pressure and fluid from the separator's extended solids collection chamber via the outlet flow's vortex/venturi effect, thereby efficiently encouraging solids into the collection chamber. System fluid shall exit the separator by following the center vortex in the separation barrel and spiral upward to the separator outlet. Supplier must submit the cross section view of their product to substantiate the presence of Vortube.

E. **Automatic Purge Valve** -- An electrically-actuated valve shall be programmed at appropriate intervals and duration in order to efficiently and regularly purge solids from the separator's collection chamber.

F. **Inlet and Outlet –** Shall be grooved/flanged couplings

G. **Purge Outlet –** Shall be threaded with a screw-on flange

H. **Piping** -- Schedule 40 galvanized carbon/mild steel; the inter piping connection of pump & separator should be MS pipes with welding / grooved fittings only.

I. **Electrical Control** – Star Delta starter with overload module; HOA selector switch; re-set/disconnect/trip switch. Power requirement: 380/415 volt, 3 phase. Minimum IP 54 Enclosure.

J. **Valves** -- Ball valves on purge line for isolation of solids-handling/purging equipment.

K. **Skid Plate** -- Steel, 3/16-inch (5 mm) minimum thickness.

L. **Paint Coating** – Shall be oil-based enamel.

2.03 Purging and Solids Handling

A. Evacuation of separated solids shall be accomplished automatically, employing a motorized ball valve with integrally-equipped programming for controlling the frequency and duration of solids purging.

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SUBHEAD-N. Electrochemical Water Treatment and Disinfection System

SCOPE

The scope of this section comprises of Design, Selection, supply, Supervision of Installation, testing & commissioning of Cooling Tower Water Treatment and Disinfection system for condenser/cooling tower water circulating system in accordance with the drawing and schedule of quantities.

The cooling tower treatment system offered must be based on electrochemical technology wherein equipment attains the chemical decomposition by electrical current. The treatment system to provide controlled electrolysis, in a reaction chamber, to prevent scaling and control formation of bacteria, algae and slime that arise in cooling water systems.

The treatment system offered must eliminate the need of any dosing chemicals for treatment of Scale, Corrosion and bio-fouling and substantially reduce the Bleed Off (Blow Down) requirement by increasing the Cycle of Concentration, thereby saving large quantity of make-up water.

INTERNATIONAL STANDARDS

The treatment system for Scale Precipitation and removal shall conform to the following International Standards-

- **ISO 9001:2000: Quality Management Standard**
- **EN 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use.**
- **Declaration of CE/UL Standards.**

SYSTEM OPERATION

The treatment system must operate using the electrolysis principle and include a reaction tank which is used as a cathode; inside the tank electrodes (anodes) are installed.

Water to flow through the tank continuously for electrical current to flow between the cathode (the tank) and the anode (electrodes inserted in the tank) and cause the dissociation of the salts in the water into ions. The cations are attracted to the tank wall, while the anions are attracted to the anodes. The anodes in the tank must be made of titanium with nickel oxide coating (Ti.Ni.O). The anodes must be resistant to high electrical current and do not dissolve in the water.

The cations include, among others, the calcium, which is the scale builder in the water. This calcium combines with carbonates present in the water and “controlled scale” is produced on the wall of the tank. The qualities of this controlled scale prevent it from adhering firmly to the tank wall, thus allowing for its scraping and flushing.

The following chemical reactions take place when an electrical current is applied to the electrodes:

An alkaline environment (pH > 9.5) is created next to the Cooling Tower Treatment System reaction tank's inner walls, which act as a cathode. As a result of this calcium and scale deposits crystallize & precipitate on the tank walls. Also this highly alkaline (and acidic near anode) environment does not permit any microorganism to survive.

The pH level in the water system does NOT change. The pH levels of the water in the reaction tank's water inlet and

water outlet are almost the same.

Next to the anodic electrodes up to 30% of the chlorides that are naturally present in the water, are transformed to free chlorine or hypochlorite (OCl-). In the electrolysis process radical oxygen and hydrogen peroxide are also being produced. Chlorine combined with the oxygen provides sufficient reduction of microbes to maintain & control of bacteria and algae in the cooling tower and further contribute to the disinfection of the water inside the reaction tank.

The scrapper throughout the tank inner height and drain valve in the Electrochemical Treatment System reaction tank remove the precipitated scale and other sediments and pollutants from the walls and volume of the tank, which prevents a breeding ground for the development or proliferation of microorganisms. This removal is fully automatic and can take place several times a day as required.

Since the Legionella bacteria is being created under conditions of stagnant water, Sediment, scale deposits, and corrosive areas, it was found that in most cases it is being prevented while using the Electrochemical Treatment System, as the system treat the surroundings that causes the Legionella growth.

The Electrochemical Treatment System to be capable to work in a maximum temperature of ~48ºC.

The Supplier must have a experience of at least 8 Years dealing with 20+ project reference in India supplying this technology and must possess calculation tools like LSI index Calculator and Mass Balance Analysis sheet.

TECHNICAL SPECIFICATIONS

Tank		
Operating Pressure	:	Maximum of 6 bar (88 psi)
Material	:	Carbon steel, epoxy painted on external side.
Tank Internals and Accessories		
Electrodes	:	Proprietary and patented metallurgy-TiNiO.
Scraper	:	Patented Polypropylene shaft and scraper of full tank inner surface scrapping , operated by motor
Valves	:	2" electrical drainage ball valve Air release/intake valve, ARI ¾”,
PH meter	:	ABB or equivalent.
Conductivity Meter	:	ABB or equivalent.
Electrical and Control Systems		
Operation Control	:	220V; 50Hz. Lambda, 24V DC. 3.1A.
Electrolysis Power Supply	:	Lambda or equivalent
Interactive Display	:	Delta or Equivalent
Electrical connection required	:	3ph, 480V, 25Amp

Components of Unitary (Single) Treatment System

- Reaction tank (serves as cathode).
- 3 Nos. TiNiO Electrodes (anodes)
- Scraper motor for scraper operation.
- Scraper made of polypropylene, mounted inside the reaction tank.
- 2" manual butterfly Inlet and Outlet valve (For Isolation in Contractor's scope)
- 2" electrical drainage ball valve
- pH and Conductivity Meter and sensors
- Automatic control electrical panel: 380V, 25 Amp.
- Air release/intake valve, ARI ¾" for protection of the tank.

Components of Mega Treatment System (Plug & Play format)(Optional)

- Multiple EST Treatment Tank
- Common Platform
- Pipes connections
- Main Circulation pumps
- Main panel control
- Main electrical box
- Main pH meter and Conductivity meter
- The container to arrive in a "plug & play" format.

MONITORING AND CONTROL FACILITIES

- The treatment system shall have the provision of automatic control by a PLC with an interactive display/HMI for monitoring of machine operation.
- HMI system shall have the provision of set up of all basic parameters for better and efficient operation of the system.
- The treatment system display unit should be able to measure the flushing time, pH and conductivity as measured by electrodes and power supply data as measured by the system in volts and ampere respectively.
- Provision for alarm acknowledge and active alarm list.
- Provision for manual flushing should also be available in the system.
- The HMI system to be operated by a password.

SALIENT FEATURES

Cooling Tower Water Treatment System should prevent

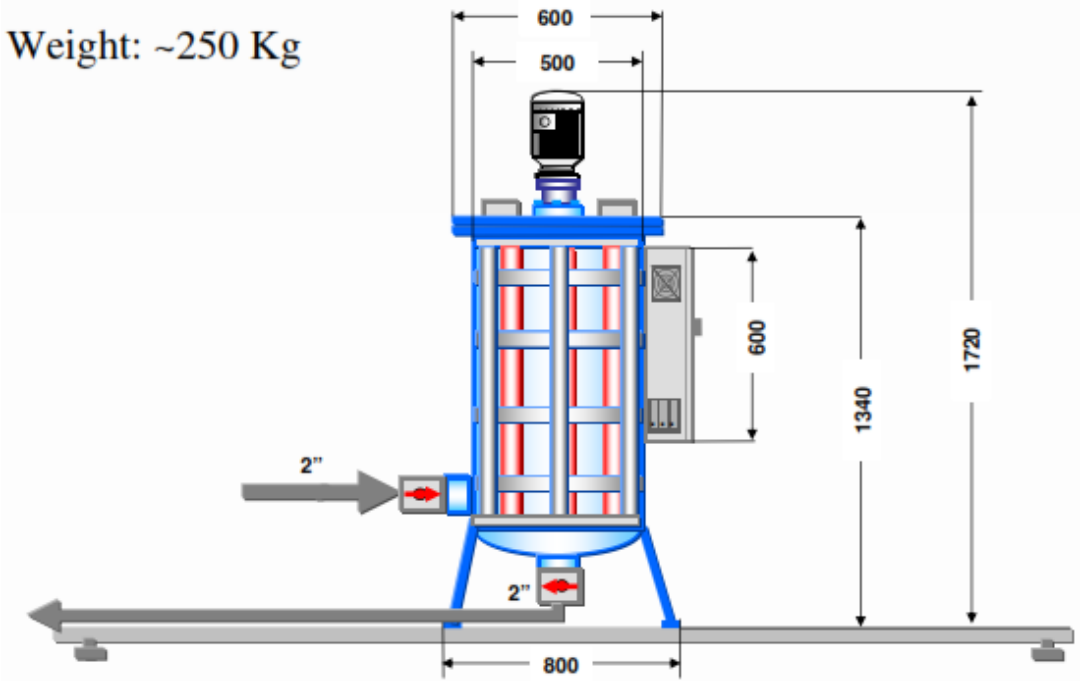
- Scale Precipitation
- Corrosion
- Bio growth and Algae
- Wastage of Blow down water

OTHER FEATURES

- Savings in Water consumption

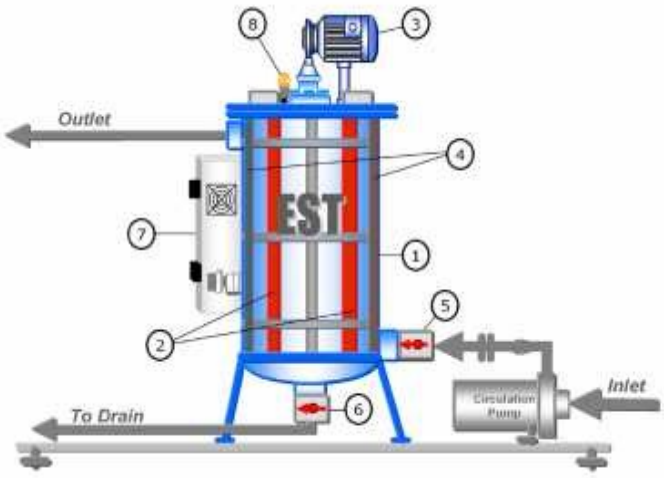
- Huge savings in Maintenance Costs
- Chemical-free: no health risks and environmental friendly.
- Exterior to the cooling tower-no changes/installations in CT
- Green sustainable Technology

Dimensional Details of a typical unitary system



Drawing 1 - Parts of Unitary Treatment System

1) Reaction tank
2) Electrodes
3) Scraper motor
4) Scraper
5) Butterfly inlet valve
6) Electrical drain valve
7) Power supply
8) Air release/intake valve



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SUBHEAD-O. AIR DISTRIBUTION

1. SCOPE

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

2. DUCT MATERIALS

2.1 RAW MATERIAL

Galvanizing sheet steel shall be conforming to IS: 277. The sheets shall have a coating of zinc, minimum of 120gm/sq.m (grams per Sq. meter) of zinc and Lock Forming Quality prime material along with mill test certificates. The duct sheets shall be lead free, Eco-friendly & RoHS compliant. In addition, if deemed necessary, samples of raw material, selected at random by owner's site representative shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

2.2 SHEET THICKNESS BY SIZE OF DUCTS (MACHINE FABRICATED)

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

For Ducts with external SP upto 500 Pa (50mmWg)

Rectangular Ducts GSS LONGEST SIDE (MM)	Gauge / Sheet Thickness
1 – 750 mm	24G (0.63mm)
751 – 1500 mm	22G (0.80mm)
1501 – 2200 mm	20G (1.00mm)
2201 and above & plenums	18G (1.25mm)

- The thickness required as per the longest side of the duct shall be applicable to all sides.

2.3 SHEET THICKNESS BY SIZE OF DUCTS (MANUAL FABRICATED)

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

For Ducts with external SP upto 500 Pa (50mmWg)

Rectangular Ducts GSS LONGEST SIDE (MM)	Gauge / Sheet Thickness
1 – 750 mm	24G (0.63mm)
751 – 1500 mm	22G (0.80mm)
1501 – 2200 mm	20G (1.00mm)
2201 and above & plenums	18G (1.25mm)

- The thickness required as per the longest side of the duct shall be applicable to all sides.

2.4 SHEET THICKNESS OF GSS FOR ROUND DUCTS (MACHINE FABRICATED) FOR ROUND / OVAL DUCTS

Duct Diameter upto 50 mm Wg (500 pa) external static pressure	
Diameter of Ducts	**(Gauge / Sheet Thickness)**
0 – 600mm	24G (0.63mm)
601 – 900 mm	22G (0.80mm)
901 – 1200mm	20G (1.00mm)
1201- 1500 mm	18G (1.25mm)

2.5 SHEET THICKNESS OF ALUMINIUM SHEETS FOR RECTANGULAR DUCTS (MACHINE FABRICATED)

Longest Side (mm)	**Gauge / Sheet thickness**
0 – 750 mm	22G (0.80mm)
751 – 1500 mm	20G (1.00mm)
1501 – 2200 mm	1.50mm
2201 & Above	1.80mm

- Aluminium sheets shall be conforming to IS:737. The thickness required for longest side shall be applicable to all the sides of the duct.

2.6 MS WELDED KITCHEN EXHAUST DUCTING

Kitchen exhaust ducting shall be fabricated with 16 G MS. Suitable access doors shall be provided at every 3m. All welded joints to be made for kitchen exhaust ducting. Provision shall be made for firefighting agency to install duct mounted sprinklers at every 3m. Generally exhaust ducts shall have slope towards kitchen hood. Kitchen exhaust ducting shall also be painted with fire resistant paint of high quality with temperature withstand of 250 deg C.

3. 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 lockformers, flangers and rollers for turning up edges.

4. DUCT CONSTRUCTION

4.1 All ducts shall be fabricated and installed in workmanlike manner, conforming to relevant SMACNA codes.

a) Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section “Insulation” and as indicated in schedule of Quantities. Duct dimensions shown on drawings, are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of quantities. The fabricated duct dimensions should be as per approved drawings and care should be taken to ensure that all connecting sections are dimensionally matched to avoid any gaps.

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

c) All Ducts shall be with TDF flanges only, be it GSS or Aluminium.

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

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

f) All sheet metal connection, partitions and plenums, required to confine the flow of air to and through the filters and fans, shall be constructed of 18 gauge GSS / 16gauge aluminum, thoroughly stiffened with 25mm x 25mm x 3mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Access doors shall be not less than 45cm x 45cm in size.

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

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

i) Guiding/Turning Vanes shall be provided where ever required and shall be securely fastened to prevent noise & vibration.

j) Splitter Dampers will be provided where ever required.

k) The vanes shall be provided wherever required and shall be securely fastened to prevent noise & vibration.

4.2a PRE-INSULATED GLASS WOOL DUCTING

Duct Acoustic (Ducting to be used up to 3-4 meters from AHU room for acoustic properties)

Pre-insulated duct board-(Neto) shall be made of high density of rigid resin bonded fire safe glass wool with outer side factory laminated aluminum foil and the inner side with black glass cloth. Outer facing foil is having - Reinforced aluminum + Kraft+ glass veil and inner facing - Black glass textile.

Duct thermal (Ducting to be used after 3-4 meters from AHU room after the Duct Accoustic)

Pre-insulated duct board (Plus –R) shall be made of high density of rigid resin bonded fire safe glass wool with both side factory laminated aluminum foil, outer facing foil is having - Reinforced aluminum + Kraft+ glass veil and inner facing foil - Aluminum + Kraft + glass veil.

Density of above both pre insulated glass wool duct board shall be 75-80Kg/m^3 and at the edge of panels shall have density of 150Kg/m^3 .Size of panels for duct construction as below.

Thickness(mm)	Length(m)	Width(m)
25	2.5	1.19

The thermal conductivity of duct board shall not be exceeding 0.034 W/m K at 25 deg C means temperature and thermal resistance should be less than 0.73 m^2·K/W.
Glass wool duct panels shall be tested as per EN 13403.

Vapour permeance of duct panels should be approximate value: 0.013 g/m² day mm Hg (outer facing)
Mechanical stiffness:

1. Duct Acoustic - One side aluminium faced and one side BGC(Black glass cloth) – R4 rigidity, according to EN 13403 (European Standard for nonmetallic ducts)
2. Duct Thermal - Both side aluminium faced - R5 rigidity ,according to EN 13403 (European Standard for nonmetallic ducts)

Duct board should withstand pressure under 800 Pa with no evidence of fissures or swelling (test according to EN 13403)
Fire test:

1. Duct Acoustic - One side aluminium faced and one side BGC(Black glass cloth : Panels shall be tested as Euroclass: Euro class B-s1, d0
2. Duct Thermal- Both side aluminium faced : Panels shall be tested as Euroclass: Euro class C-s1, d0

- s1: null smoke emission
- d0: non flaming droplets / particles.

Joint System: Duct boards should have exclusive design with male / female edges, in order to provide greater strength for joints, easy installation and shall reduce the number of cutting operation & exceptional inside finish.

Tools and Accessories for Installation of Duct Boards shall be followed as per recommendation of manufacturer's manual.

Duct Support: Duct board shall be installed, using support as described in installation manual of manufacturers. Maximum distance between hangers / support shall not exceed for horizontal ducts as

- 900 mm inner dimension maximum distance of hanger 2.4 m
- 900-1500 mm inner dimension maximum distance of hanger 1.8mm
- Above 1500 mm inner dimension maximum distance of hanger 1.2 m

INSPECTION AND TESTING

Duct dimensions shall be checked based on the duct dimension / layout drawings duly approved by the Architects/ Consultants.

The ducts, branches elbows etc. shall be inspected and the joints and connection shall be checked properly before these are assembled in position. After assembly the system shall be checked for tightness of male/ female joints to avoid the leakage Climaver Al. tape of 75mm thickness shall be applied on each male / female joint to avoid the leakage of air

Full sized standard dimension sheet as specified are to be used and any patched or made-up pieces of duct work are liable to be rejected. Joints between male/ female connections shall be fitted properly and Al. tape of 75 mm thickness shall be applied on joints.

Test points shall be provide at the discharge of each air handling unit and at each individual zone of the duct work system. Test points shall consist of 25mm diameter sockets fitted with sealing plugs which can be removed for the fitting of measuring devices. Test points shall be insulated as for the duct work and shall be provided with identification labels.

Rectangular risers should be free supported by angles or channels secured to the sides of the duct flanges with bolts or sheet metal screws or blind rivets. The supporting angle or channel should be freely resting over the slab cut-out. Riser support intervals should be limited to one storey height.

Restrictions of use:

- Outdoor placed ducts and ground buried applications
- Vertical ducts □ 3 m without reinforcements
- Smoke or gasses evacuation

Use limits

- Static pressure >800 Pa (80 mm c.a.)
- Air speed > 18 m/s
- Internal air temperature > 90ºC
- External air temperature > 65ºC

To ensure the air tightness, all ducts shall be checked with Leak Test after completion of duct fabrication but before installation of duct system.

4.2b. Pre-insulated ducts (PIR)

Pre-Insulated Ducting shall be fabricated from 20 mm thickness air duct panel sheet having dimensions of 3000 (Length) mm by 1200 (Width) mm and produced and Sandwiched with Polyisocyanurate (PIR) first quality insulating Foam having 35 Kg / m^3 density. The Ducting Sheet shall have Lacquered & Embossed Aluminium facing on both sides.

Insulating foam material shall be Expanded Rigid Polyisocyanurate foam having closed cell content not

less than 95%, CFC/ HCFC free, Non Toxic, Non combustible, zero ozone depletion, Zero Global Warming Potential and Non ignitable.

Ducting panels shall comply with following or equivalent standards and manufacturer should produce M1 & F1 certification for Fire & Toxicity test results.

- BS 476: PART 6--Fire Propagation for Products
- BS 476: PART 7--- Surface Flame Spread (Class 1)
- Class O Fire Rating as per Building Regulation requirements.
- Thermal Conductivity Coefficient at 10^0C--0.022 W/m. K
- Smoke Opacity Index—less than 10
- Rigidity class: 200000 Nm m^2/mm
- Water vapor permeability of laminations = 0

All required accessories; Connecting Flanges, Invisible Bayonet, Adhesive, Sealant, Duct Supports (as per clause 5.2) shall be part of ducting work for fabrication of the HVAC ducting in Square, rectangle, radius, offset construction etc., appropriate sizes of Aluminium flanges with self-adhesive good quality gasket shall be provided as a joinery or connection of duct pieces.

All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes (as per clause 5.2) and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be**.** The spacing between supports should be not greater than 3.0 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using self-grip double channel lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners.

Excellent quality Silicon Neutral Sealant of Approved make along with fire rated PVC corners shall be used for sealing of all joints & corners.

Complete ducting shall be installed incorporating duct supports such as galvanized angles, threaded rods, self adhesive brackets, Etc.

Panel Specifications:-

Description	Internal Areas	External Areas of Building
Dimensions of panel	3000 x 1200 mm	3000 x 1200 mm
Thickness of panel	20 mm	20/30 mm
Thickness of aluminium laminations	60/60 microns	60/200 microns
Density of the foam	35 kg/m^3	35 kg/m3
Surface finish	Embossed/Embossed	Embossed/Embossed
Anti-rust lacquer	2 gm/m^2 both sides	2 gm/m^2 both sides

4.3 FLEXIBLE DUCT:

General:

The scope of this section comprise supply, installation, testing and commissioning of flexible ducting conforming to these specification and in accordance with requirements of drawings and schedule of quantities.

Duct Materials:

a. Un Insulated Flexible duct

Uninsulated flexible duct shall be made of Aluminum core permanently bonded to a coated spring steel wire helix. Duct shall be in tear and puncture resistant construction.

b. Insulated Flexible Duct

Wherever insulated flexible duct are specified inner core for the same should be made of double lamination of Aluminium film permanently bonded to a coated spring steel wire helix. Blanket of fibre glass insulation of R 4.2 (RSI - 0.76 m2K/W) having density of 24 kg/m3 and thickness of 25 mm shall be wrapped over the inner core & covered with tear and abuse resistant outer jacket cum vapour barrier made of Pure Aluminum Foil.

Installation:

Care must be taken to install all the flexible duct in fully extruded position and bends made with adequate radius as per manufacturer recommended practices.

Hangers and Supports

The flexible duct must be installed fully extended to produce optimum results.
The maximum allowable sag, between any two adjacent suspension points, should not exceed 50 mm per meter.

The distance between any two adjacent suspension points may vary from 1.50 to 3.00 meter, depending upon the type of flexible duct in use.

Flexible ducts mounted above suspended ceiling should always be independently supported. Ducts mounted in these locations are susceptible to damage whenever ceiling panels need to be periodically interchanged, unless they are separately supported.

Bending Radius

All bends should be made as large as possible and should have a radius of not less than the diameter of the duct in use. This reduces un-favorable pressure losses and is particularly important for metal based products which are more susceptible to stress rupturing. Double bends should be avoided, however if un-avoidable, ensure that each radius is not less than R = 2 x D.

Straps

Ideally the hanging straps should supports the flexible duct with a minimum of half the circumference surface in contact, and without reducing the effective inside diameter of the duct. It is also recommended that the minimum width of material to be used for the hanging straps should be at least 25 mm.

Flexible Duct to Conventional Duct Connection

Extra care should be taken when making connection to fixed conventional ducts, etc., and ensure that they do not become too stressed. An additional support is recommended to obviate this potential problem.

Metal based flexible duct products are particularly prone to fracturing due to stress caused as a result of sharp connection.

Connections to ceiling illumination “troffer boxes” should be served in the most direct manner similar to that described for conventional ducts.

Too many bends, when connecting to “troffer boxes” and / or any other type of air supplying component, may result in excessive pressure loss and the generation of noise.

Longer Length Installation

In the event where extreme length of flexible duct is to be installed, round duct connectors made of galvanised sheets of at least 30 cm long should be used to connect the duct at every distance of 10 meters. Use metal or galvanised hangers as recommended (point 3) to support the point where connectios are made. Light railing is a good alternative hanging support when using long length of flexible duct.

Direct Contact
It should be emphasized that the flexible duct must not be in direct physical contact with un-insulated heating or hot process pipes. If in the event where such situation cannot be avoided, additional 1" thick insulation should be wrapped around pipes that are in contact with the duct.

4.3a. Insulated Flexible ductwork
Insulated Flexible ductwork shall be as described in the SMACNA Low Pressure Duct Standards (5th Edition).

a. Where flexible connections are indicated or required between rigid ductwork and particular components or items of equipment, the internal diameter of the flexible duct shall be equal to the external diameter of the rigid ductwork and of the spigot served. The use of flexible duct between rigid sections of sheet metal ductwork to change direction or planes will not be permitted except where indicated or expressly authorized by the Owner.

b. The flexible duct shall have a liner and a cover of tough tear-resistant fabric equal in durability and flexibility to glass fibre and shall be impregnated and coated with plastics.It shall be reinforced with a bonded galvanized spring steel wire helix between the liner and the cover and an outer helix of glass fibre cord or equal shall be bonded to the cover to ensure regular convolutions.

c. Alternatively the flexible duct shall consist of flexible corrugated metal tubing of stainless steel, aluminium, tinplated steel or aluminium coated steel. The metal may be lined on the inside or the outside or both with plastics material.

d. The joints of rigid spigots shall be sealed with a brush coat of pipe jointing paste or mastic compound. Ducts up to 150mm diameter shall be secured with a worm drive type hose slip.Ducts over 150mm diameter shall be secured with a band clip.

e. The frictional resistance to air flow per unit length of the flexible duct shall not exceed 50% more than the frictional resistance per unit length of galvanized steel ducts of equivalent diameter. The radius ratio R/D for bends shall not be less than 2, where R is the centre line radius and D is the diameter of the flexible duct.

f. Flexible ductwork shall not pass through fire/smoke resistant building construction nor be used at extract points where deposits of flammable substances are likely to occur in high fire risk areas.

g. The leakage from any section of flexible duct shall not exceed 1% of the design air flow rate at the static operating pressure.

h. Flexible ducts shall be suitable for an operating temperature range of -
18^{o}C to 120^{o}C and shall comply with BS 476 Part 1, Section 2, Clause 7 (Class 1: Surface of very low flame spread).

5. INSTALLATION PRACTICE

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

a. 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.

b. 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.

c. 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.

d. All ductwork shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with hangers formed of galvanized steel wire ropes and galvanized steel angle/channel or a pair of brackets, connected by galvanized steel wire hangers under ducts, rigid supports may be provided at certain interval if need be**.** The spacing between supports should be not greater than 2.4 meter. All vertical ductwork shall be supported by structural members on each floor slab. Duct supports may be through galvanized steel insert plates or Toggle end wire fixing left in slab at the time of slab casting. Galvanized steel cleat with a hole for passing the wire rope hanger shall be welded to the plates. Trapeze hanger formed of galvanized steel wire rope using self-grip double channel lock shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash/anchor fastener driven into the concrete slab by electrically operated gun. Wire rope supports shall hang through the cleats or wire rope threaded studs can be screwed into the anchor fasteners. In case of PEB structure Loop and Catenary system can be used based on the site conditions as per approved suspension system drawings.

e. 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.

f. 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 or shall be fire sealed (by another specialist agency).

g. 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.

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

6. DUCT'S SUPPORTS & HANGERS:

Various Ducting supporting system details are as mentioned below:

a. Ducting supports system as per NBC-2016, Page 64, Part 8, Section 3 (Clauses: 12.1.7.1 to 12.1.7.3):

Supporting details for **low pressure rectangular ducting** system are given below:

Larger side of Duct	Supporting angle	Vertical Rod Diameter	Maximum spacing between supports
(mm)	(mm)	(mm)	(mm)
Upto 900mm	40 x 40 x 5	8	2400
901 to 1500mm	40 x 40 x 5	8	2400
1501 to 2400mm	40 x 40 x 5	10	2400
2401 and above	65 x 65 x 5	12	2400

Supporting details for high pressure rectangular ducting system are given below:

Larger side of Duct	Supporting angle	Vertical Rod Diameter	Maximum spacing between supports
(mm)	(mm)	(mm)	(mm)
Upto 1250 mm	50 x 50 x 5	12	2400
1251 to 2100 mm	65 x 65 x 5	12	2400
2101 and above	75 x 75 x 5	15	2400

b. Duct supports system with Wire & Hanger Support System:

Wire Hangers shall be used to suspend all static HVAC Air Distribution services.

Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10) stud, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a self-locking lockat the other end with double channel locking arrangement. Once the lock is engaged, for safety purpose, unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking grip. . In case unlocking arrangement is an integral part ie. button/pin type, the button/pin shall be hidden under a separate housing cover made of same material as of housing. To guard against accidental unlocking, the unlocking button/pin should be accessible if and only if the housing cover is removed. Only wire and/or supports supplied and/or approved, shall be used with the system.

- Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, CSA, ADCAS, , ECA, and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002 standards. If product is not certified by SMACNA and manufacturer is giving compliance to SMACNA then the wire dia. selection shall be as mentioned in SMACNA Chapter 5, Tables 5-1, 5-1M, 5-2 and 5-2M.
- Wire Hangers shall be independently tested by reputed third party testing organization to sustain safe working load for 120 minutes at elevated temperature of 175 deg. C or above.
- The contractor shall select the correct specification of wire hanger to use for supporting each particular service. Each size should be designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).

The correct specification of wire hanger required should be determined using the following formula or as per manufacturer's recommendation, whichever is stringent.

Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).

Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook.

The contractor shall select the correct length of wire rope required to support the service. The contractor shall select the correct length of wire rope required to support the service. No in–line joints should be made in the rope.

The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302 (1987), BSEN12385. **Comply with manufacturer's load ratings and recommended installation procedures.** Note the testing is done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

HVAC Supports – Wire Rope Hanger Supports are suitable for: Rectangular duct, Spiral Duct, Oval Duct, Fabric Duct, Desertification fans, Air Conditioning Units, Plenum Boxes, Radiant Panels, Heaters, Fan Coil Units, Diffusers and Chilled Beams.

i. **Standard Ducting Supports:**

Ducting over furred ceiling shall be supported from the slab above or from beams after obtaining approval of Construction manager/consultant. 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.

ii. Special Supports: Refer to manufacturer's recommendations on Catenary supports, special care should be taken with tensioning of the wire and angles at which the installation of services are made**.** Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.

Refer to manufacturers catalogue and installation guide for further technical information.**Comply with manufacturer's load ratings and recommended installation procedures.**

Notes: All supports are considered at 2400 mm interval and may vary as per the design but should not be greater than 2400mm.

Desertification fans, Air Conditioning Units, Plenum Boxes, Radiant Panels, Heaters, Fan Coil Units, Diffusers, Cassette units and Chilled Beams.

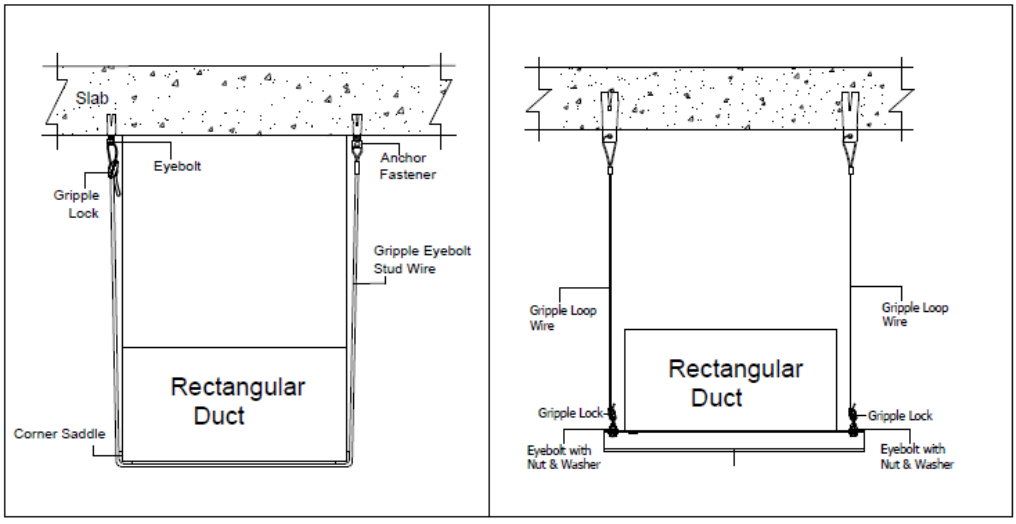
All units shall be adequately secured and supported in an approved manner using wire hanger suspension Y fit solution as per manufacturers' recommendation with prior approval.

Rigid Supports:

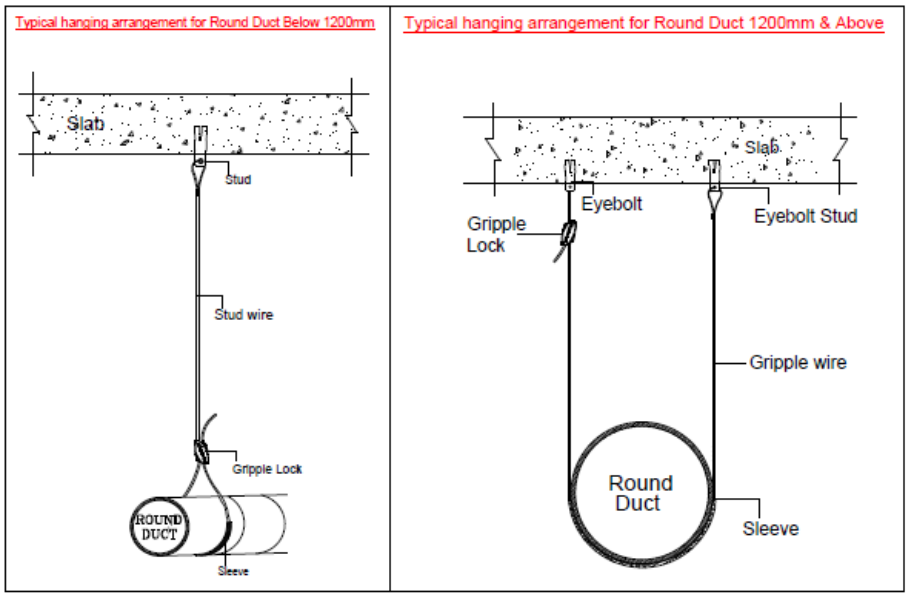
Rigid supports if required in conjunction with wire hangers, as per manufacturer recommendation, shall be of steel, adjustable for height and Zinc chromate primer coated and finish coated black, Galvanized Strut support system of required strength and profile can also be used. Where supports and clamps are of dissimilar materials, a gasket shall be provided in between.

iii. Typical Arrangement for Duct Supports from RCC slab

Typical Arrangement Rectangular Duct for Slab Area

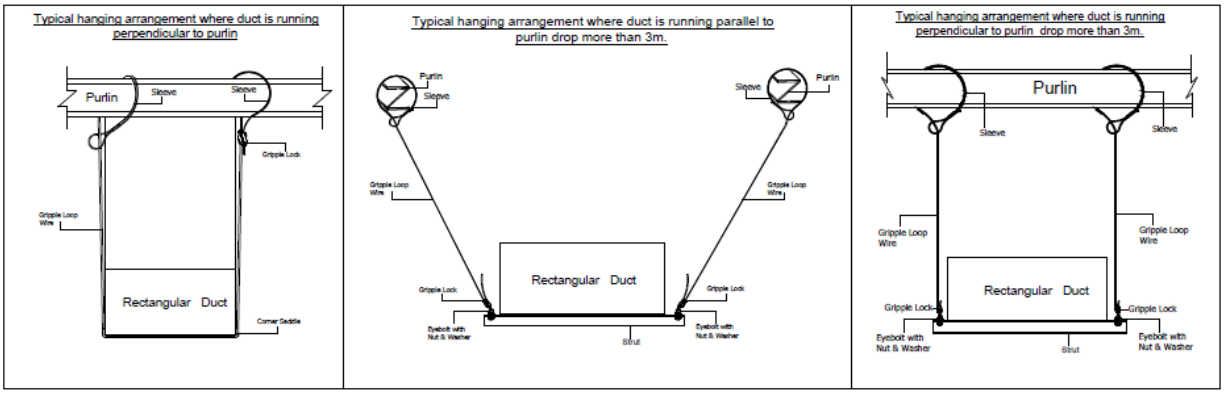


Typical Arrangement Round Duct for Slab Area

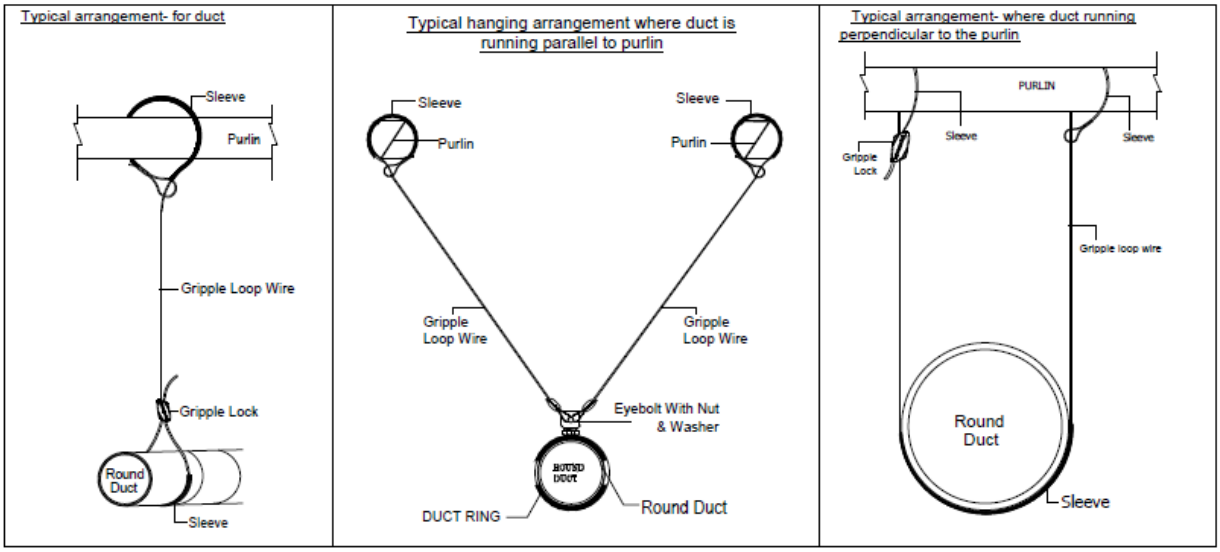


iv. Typical Arrangement for Duct Supports from PEB

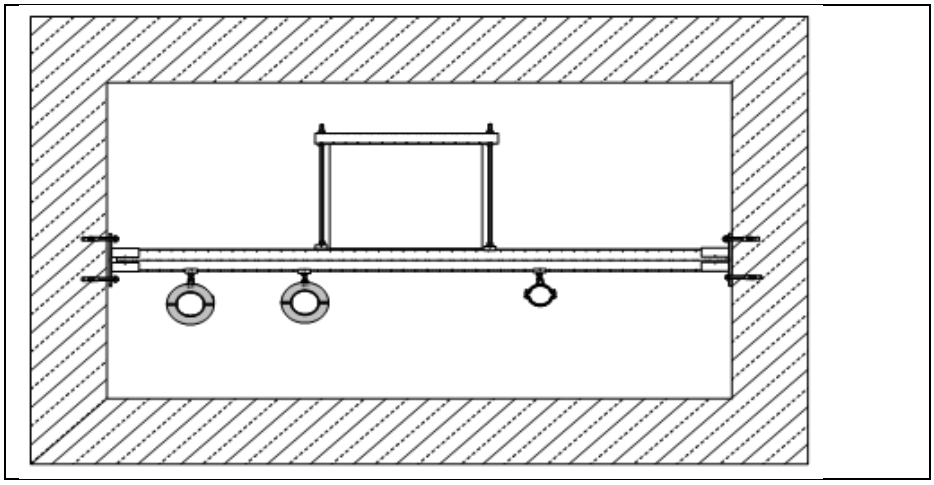
Typical Arrangement Rectangular Duct for Structure Area



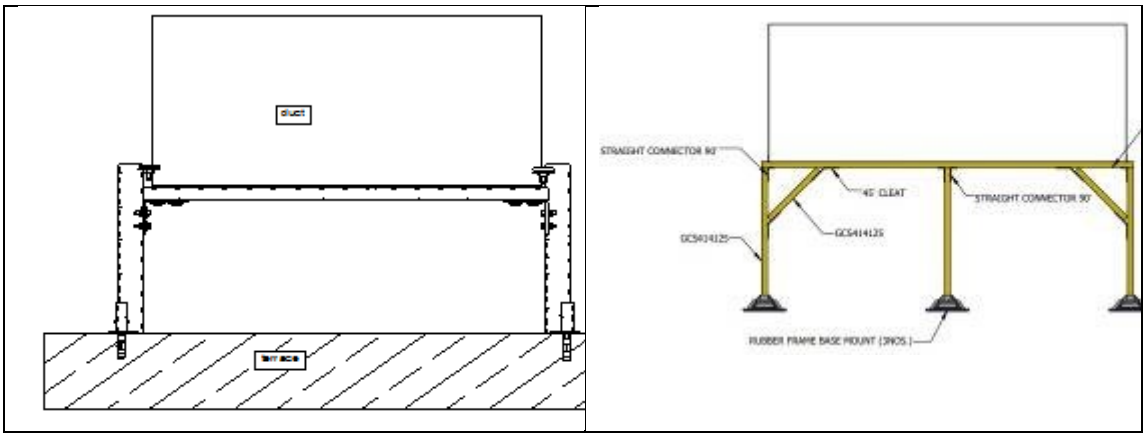
Typical Arrangement Round duct for Structure Area



v. Typical Arrangement for Duct, CHW pipe and drain pipe support from building shaft

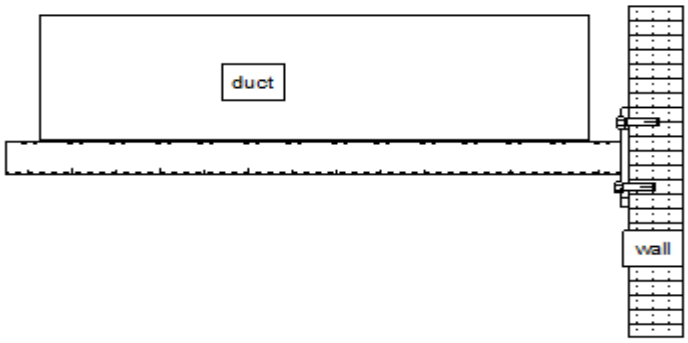


vi. Typical Arrangement for Duct Support on terrace:



Note: Foot based supports should be used for terrace/floor application to avoid anchorage/drilling on terrace/floor.

vii. Typical arrangement for duct support from wall:



The struts/channels used shall be made of pre-galvanized sheet as per IS standards. Contractor shall submit load calculation sheet and stress analysis of all struts/channels, brackets etc which shall be carried out by using a reputed third-party modeling/analysis software.

Note: Contractor shall be fully responsible & accountable for the structural stability of the hanging / supporting system of duct work. The above data furnished about supports is only for guidance. The ducting contractor to hire a specialist agency / vendor to design the supporting system of duct work and submit a design & certificate along with supporting marked drawings with typical supporting arrangements.

All the supporting system should be supplied from same manufacturer. And a structural stability certificate to be issued by the duct installation /HVAC contractor to the client along with the design.

c. SEISMIC RESTRAINTS & SEISMIC VIBRATION ISOLATION FOR NON-STRUCTURAL COMPONENTS FOR MEP EQUIPMENT & DISTRIBUTION.

i. INTRODUCTION:

This specification is intended to provide general guidelines for the Seismic Analysis of Non-Structural components ie. MEP & FF distribution & equipments

ii. SCOPE:

Seismic Analysis/Calculations should be carried out based on IS16700:2017. References from IS16700:2017 should be taken for seismic forces. Exceptions for Seismic supports as stated in ASCE7, SMACNA seismic restraint manual should be considered. For Fire-fighting distribution components & equipment sway bracing design and exceptions mentioned in NFPA 13 will supersede exceptions mentioned in ASCE 7.

iii. DESIGN LOADS:

DEAD LOADS

The dead load is assessed based on the weight of the equipment/distribution system.

SUPERIMPOSED DEAD LOAD

The super imposed dead load is assessed based on the weight of the equipment / distribution system. For pipes containing water, weight of the water filled pipe is included in this load case.

EARTHQUAKE LOAD

Earthquake load should be calculated as per IS16700:2017, appropriate references from ASCE 7-10 should be considered considered

As per IS16700:2017/NBC 2016, following parameters should be considered

Seismic zone should as per NBC 2106 Part 6 Section 1 or as per building design seismic zone factor.
Seismic zone factor, Z – 0.24 (ZONE IV-Delhi NCR Region), as per NBC 2016 Part 6 Section 1 Table 42 Clause 5.3.4.2.
Seismic Design Force is calculated as IS16700:2017, as follows

Fp = Z * (1+x/h) (ap * Ip/Rp) Wp ≥ 0.10 Wp (As per IS16700:2017)

where,

Z = seismic zone factor given in NBC 2016 Table 42 (Clause 5.3.4.2) should be considered.

g.) Zone factor for some important towns are given at NBC 2016 Part 6 Section 1 Annexure K or as per building design seismic zone factor = 0.24 (Zone IV)
h.) Response Reduction Factor should be taken as per IS16700:2017.
i.) Amplification factor (as per IS16700:2017)
j.) Importance factor, Ip (as per IS16700:2017)
k.) z - Height in structure of point of attachment of component with respect to the base.
l.) h - Average roof height of structure with respect to the base

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

WIND LOAD ANALYSIS:
Calculate static and dynamic loading due to wind forces required to select/design vibration isolators, bases and seismic & wind restraints for outdoor & roof top equipments/services. The calculation of wind load shall be as per IS:875(Part 3)/NBC 2016 Part 6 Section 1. Worst case between Seismic Loads and Wind Loads has to be considered for supporting and vibration isolation.

iv. ANALYSIS METHOD

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

v. DESIGN METHODOLOGY

The supporting structural steel system shall be designed according to Limit state method as specified in IS: 800-2007. Appropriate loads and its combinations, as per relevant clauses in IS codes should be chosen for design. Based on selection location and type of seismic support for the same shall be provided in the shop drawings.

vi. LOAD COMBINATION

The various loads are combined in accordance with the stipulations in NBC2016.
Load combinations considered in design are as follows,

Type	Load Case	Load Details
Primary	1	Dead Load-DL
Primary	2	Superimposed dead Load at Terrace- SIDL
Primary	3	Earthquake Load along X-Direction EQ(+X)
Primary	4	Earthquake Load along Z-Direction EQ(+Z)
Primary	5	Earthquake Load along Y-Direction EQ(+Y)

LOAD FACTOR FOR LOAD AND RESISTANCE FACTORED DESIGN (LRFD):

0.9 DL ± 1.5 (Eqx ± 0.3 Eqy) …… NBC2016 5.3.3.4

vii. MATERIALS:

Structural Steel:

Materials	Standards
Hot-Rolled Members	
ISMC Channels	IS:2062
Angles	IS: 2062
Bolts & Nuts	Grade 4.6
Anchor fasteners	Grade 8.8
Cold-Formed Members	IS:811

Seismic Wire Rope Kit:

Wire based seismic restraint kits shall consist of Break strength certified, pre-stretched seismic cable with a permanently fixed 45 degree eyelet or ferruled copper/copper plated loop fixed to single, double or retrofit seismic bracket, or any other end fixture type or size as per manufacturers recommendation and design. The end fixing, bracket and wire must be of the same manufacturer. The system should be secured and tensioned with a Seismic rated self-locking grip at the other end. For ease of installation, flexibility, and workmanship only wire based seismic restraint system shall be used to restraint/brace all services.

Wire seismic restraints supplied and/or approved, shall be used with the system, the wire rope should not have color coding applied to it and should only be supplied with separate color coded tags. Bracing elements shall be seismic certified/tested by third party accredited lab as per ASHRAE standard 171, Method of Testing for Rating Seismic and Wind Restraints.

Cables shall have color coded size identifiers as per seismic requirements and must be pre-stretched. Cables shall be suspended 45 degrees (+/- 15 degrees Engineers allowances). Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and unlocking button should not be an integral part of the self-locking grip for safety purpose.

At the point of the seismic restraint installation, a rigid support is required (threaded rod + rod stiffener or appropriate as approved by a qualified engineer). The location of all the seismic restraint points shall be determined by a qualified engineer.

When attaching the seismic restraints to the slab/structure seismic rated anchor shall be used. The connection of channel/ stiffener to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

The seismic product to be used shall be determined by a qualified engineer, based on data supplied by the manufacturer.

The contractor shall select the seismic bracket for the attachment to the ‘service’ as either a standard or retrofit bracket. All parts and materials shall have been fully tested to conform to local/ state/provincial requirements and codes. The same manufacturer shall supply all parts and materials

The designer/contractor shall select the correct specification of wire based seismic restraints to use for restraining/bracing particular service mentioned in this specification; approved concrete anchors must be used by the designer/contractor. Refer to Table 1 below.

The Seismic engineer shall select the correct length of wire rope required to restrain/brace the various services & applications. No in–line joints should be made in the rope.

Table 1:

Wire based seismic restraint Safe Working Loads	
Kit Type	**Design Strength (LRFD) (kg)**
Type 2	239
Type 3	522
Type 4	1261

All Seismic restraints must comply with manufacturer's load ratings and recommended installation procedures.

Threaded Rod:

Size	Threaded Rod Diameter (mm)	Allowable Working Load (kN)	Allowable Working Load (kgs)	Max Unbraced Rod Length (mm) Table 7-5 ASHRAE Seismic Manual
M10	10	2.7	275.23	457
M12	12	5	509.68	635
M 16	16	8	815.5	584
M 20	20	12	1223.24	610
M 22	22	16.7	1702.34	660

Rod Stiffeners:
Rod stiffener consisting of steel channel and attachment clips capable of bracing vertical suspension rods or made out of Polypropylene to avoid potential buckling due to vertical compression forces should be used. Braces shall be selected to be of sufficient strength to prevent support rod buckling. Brace shall be attached to the vertical suspension rod by a series of attachment clips.

Riser Guides:
Risers shall be restrained against excessive lateral movement during service/earthquake. Riser guides must allow axial motion of the pipe and provide lateral restraint against static, hydrostatic & earthquake loads. The guides should include a neoprene bushing. This bushing allows some flexibility and prevents short-circuiting of vibration isolated device. The neoprene bushing also allows seismic loads to be cushioned and distributed to several guides.

Riser Anchors:
Straight solid risers can be rigidly anchored at one point provided the load is not concentrated on one floor. Riser anchors must be able to restraint against static, hydrostatic & earthquake loads. Riser anchor should restraint against excessive movement during services and earthquake thrusts by the use of 3-axis resilient anchors designed to withstand the required installation, operating and earthquake loads. Anchors shall be of steel construction and shall be attached to the riser with either a heavy-duty riser clamp or a welded support bracket in a manner consistent with anticipated design load. Snubbers shall limit lateral and vertical riser movements at each anchor location to a maximum of ¼" (6mm) in any direction. Anchors shall include a minimum of ½" (13mm) thick resilient neoprene pad to cushion any impact and avoid any potential metal-to-metal contact. Anchors shall be capable of withstanding an externally applied force of up to their rated capacity in any direction.

Riser Clamps

Riser clamps should be two-piece heavy-duty clamps bolted together and have a load rating based on clamping capacity. Riser clamps reinforce the pipe and distribute forces evenly to minimize pipe wall stress concentrations that would otherwise develop with welded lugs or brackets. The clamp must be sized for two times the dead load and there must be a positive means of engagement between the clamp and riser.

All Directional Seismic Restraint Spring Mounts

Spring isolators shall be single or multiple coil spring elements which have all of the characteristics of free-standing coil spring, incorporating lateral and vertically restrained seismic housing assemblies. Restraint housing shall be sized to meet or exceed the force requirements of the application and shall have the capability of accepting coil springs of various sizes, capacities, and deflections as required to meet the required isolation criteria. All spring forces shall be contained within the coil/housing assembly, and the restraint anchoring hardware shall not be exposed to spring generated forces under conditions of no seismic force. Spring element should have built-in levelling adjustment and shall be accessible from above and suitable for use with a conventional, pneumatic or electric impact wrench. Restraint element shall incorporate a steel housing with elastomeric elements at all dynamic contact points. Elastomeric elements shall be replaceable. Restraint shall allow ¼" (6 mm) free motion in any direction from the neutral position. Isolators should have a min. operating Kx/Ky ratio of 1.0, springs should have 50% additional travel to solid beyond rated load. Isolators should be selected in the range of -30% to +25% of rated load. All isolators certified to withstand minimum 1.0 G force. Seismic 'G' ratings for all seismic restraint products should be 3rd party certified and should be part of relevant submittal. Spring elements should be color-coded for easy field verification and should be capable handling high deflection and should have a low natural frequency.

Modular Support Components:

C-channel vertical suspension shall be selected to be of sufficient strength to prevent support buckling. Wire rope brace shall be attached to the connector connecting vertical suspension C-channel/threaded rod/stiffener with horizontal C-channel by a suitable connector capable of taking seismic loads. Stress analysis calculation should be submitted for the worst-case length of the C-Channel/Strut members used. Stress analysis should be done for tensile, compressive and combined stresses.

The connection of wire rope bracing /channel/ threaded rod to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

Flexible Connections/bellows for accommodation of differential seismic motion:

Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement. Install flexible connectors where adjacent sections or branches are supported/ connected by different structural/non-structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural/non-structural element from the one supporting the connections as they approach equipment. All installed bellows and flexible connections shall be designed to accommodate for seismic motion and deflection.

viii. SERVICABILITY REQUIREMENTS:

Deflection:

Deflection Limitations shall be as per 5.6.1 Table 6 of IS800:2007

ix. Seismic bracing Design:

Seismic Supporting system shall be analyzed for seismic forces as per IS 16700 Cl. 10.2 and design intent of SMACNA seismic restraint manual - Guidelines for Mechanical system; ASCE 7-10 Chapter 13 and ASHRAE Practical Guide to Seismic Restraint shall be used as a reference for design basis & exceptions. The load calculations, stress calculations, design basis and exceptions considered shall be part of submittal for approval.

Project Design Criteria:

To be mentioned in the submittal documents:

Description	Standard
Seismic Zone	IS16700:2017
Seismic Zone factor	NBC 2016 Table 42 (Clause 5.3.4.2) or as per building seismic zone factor.
Soil Site class	as per site location
Importance Factor (Ip)	IS16700:2017
Component amplication factor (ap)	IS16700:2017
Component response modification factor (Rp)	IS16700:2017
Component response modification factor (Rp) for base isolation	IS16700:2017
Height in structure of point of attachment of component with respect to the base (z)	As per level of attachment of component
Average roof height of structure with respect to the base (h)	As per level of attachment at the roof/slab/peb level
z/h	ratio based on above parameters

For Calculations:

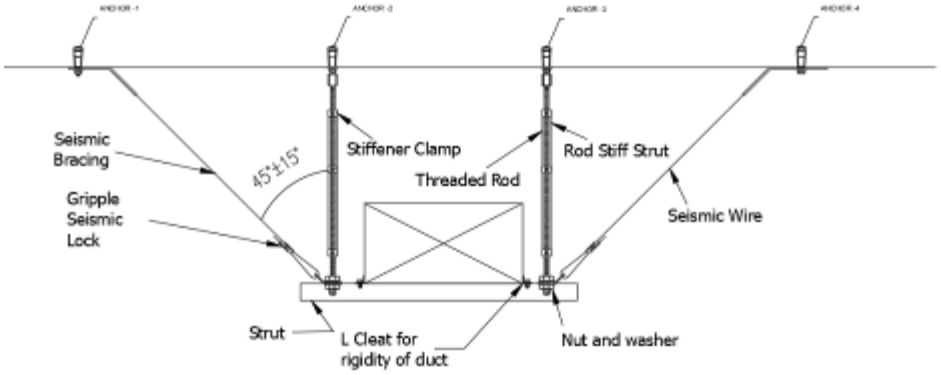
Description	Formula & Values
Seismic Design force In horizontal direction (Fp')	to be part of submittal
Vertical seismic force (Eqy')	to be part of submittal

Maximum Distance between Bracing for Ducts:

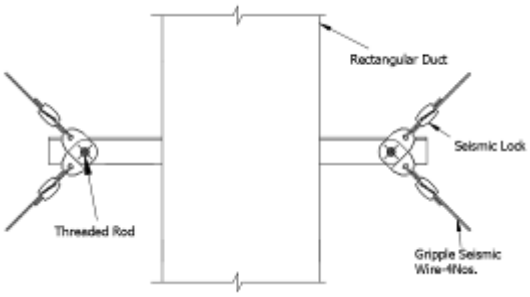
Maximum Seismic Acceleration Input (*g*)	Maximum Transverse Brace Spacing, ft (m)	Maximum Longitudinal Brace Spacing, ft (m)
0.25	40 (12.2)	80 (24.4)
0.50	30 (9.1)	60 (18.2)
1.0	30 (9.1)	60 (18.2)
2.0	20 (6.1)	40 (12.2)

Typical arrangements for seismic supports:

Two Way Bracing:



Four Way Bracing:



NOTE: DUCTING SUPPORTING SYSTEM TO BE DESIGNED BY A COMPETENT AGENCY TO ENSURE SAFETY OF THE INSTALLATION, BUILDING AND THE PERSONS. CONTRACTOR TO HIRE A SPECIALISED AGENCY FOR DESIGN AND INSTALLATION OF THE DUCT SUPPORT SYSTEM AND ASSUME COMPLETE RESPONSIBILTY ON ADEQUACY OF THE SUPPORT SYSTEM. CONTRACTOR TO SUBMIT A CERTICATE FROM THE STRUCTUAL CONSULTANT ALONG WITH THE DESIGN AND DRAWINGS SUBMITTED TO THE CLIENT/PMC.

7. VOLUME CONTROL DAMPERS FOR AIR BALANCING / AIR CONTROL(MANUAL/MOTORISED TYPE):

i. GSS CONSTRUCTION TYPE:

1. All GSS duct dampers shall be opposed blade louvres design.
2. It shall be a multi-blade sturdy steel construction damper.

A. Type of Dampers:

a. Duct dampers: shall be placed in every branch of supply or return air ducting system, whether shown in the drawing or not.
b. Fresh air / Exhaust air dampers: shall be fixed to wall shaft opening as the case may be.

B. Damper Operation:

a. Dampers shall be either manual operated or motorized.
b. Manual dampers shall have a handle & Motorized dampers shall a non-spring return actuator. The actuator selection shall be based on the torque requirement.
c. Manual dampers shall have indication of blade position.
d. Motorized dampers shall have actuators suitable for fully open or close position or shall be of modulating type as the case may be.
e. Actuators for the motorized dampers shall have status communication provision to BMS.
f. Actuators shall be of 230V, AC, 1 phase supply or 24V AC / DC supply. Power to actuators shall be drawn from the DDC controller of BMS, it shall be factory fitted.
g. Actuators shall be controlled by BMS / HVAC controls as the case may be.

C. Constructional Features:

GSS Construction:

1. All GSS duct dampers shall be opposed blade louvres design.
2. It shall be a multi-blade sturdy steel construction damper.
3. Damper construction shall be such that it offers least turbulence to air flow & offer minimum pressure drop.
4. All blades shall be interconnected using linkage in the frame section out of air stream, when needed the jamb seals shall be stainless steel flexible metal compression type.
5. Each blade shall have axles supported on both sides with corrosion resistant bearings turning in the extruded hole in the frame.

Constructional Details	
Frame Material	Galvanized Steel
Frame Material Thickness	1.6mm
Frame Type	C- Channel – 165mm deep with 30mm Flanges
Blade Material	Galvanized Steel
Blade Material Thickness	1.6mm
Blade Type	Triple V Type
Linkage	In Frame
Axle Bearing	Lexan Bearings, pressed into Frame
Axle Material	Plated Steel

Dimensional Limitations	
Single Section	Multiple Section
1200mm H x 1200mm W (Maximum)	2400mm H x 2400mm W (Maximum)
150mm H x 200mm W (Minimum)	

ii. **ALUMINIUM CONSTRUCTION TYPE:**

1. All Aluminium duct dampers shall be opposed blade louvres design.
2. It shall be a multi-blade sturdy Aluminium construction damper.

A. Type of Dampers:

a. Duct dampers: shall be placed in every branch of supply or return air ducting system, whether shown in the drawing or not.
b. Fresh air / Exhaust air dampers: shall be fixed to wall shaft opening as the case may be.

B. Damper Operation:

a. Dampers shall be either manual operated or motorized.
b. Manual dampers shall have a handle & Motorized dampers shall a non-spring return actuator. The actuator selection shall be based on the torque requirement.
c. Manual dampers shall have indication of blade position.
d. Motorized dampers shall have actuators suitable for fully open or close position or shall be of modulating type as the case may be.
e. Actuators for the motorized dampers shall have status communication provision to BMS.
f. Actuators shall be of 230V, AC, 1 phase supply or 24V AC / DC supply. Power to actuators shall be drawn from the DDC controller of BMS, it shall be factory fitted.
g. Actuators shall be controlled by BMS / HVAC controls as the case may be.

C. Constructional Features:

Aluminium Construction:

Multi blade Aluminium construction damper shall be made with 1.6mm thick Extruded Aluminium frame & 1 mm thick extruded aluminium blade shall be of Aerofoil design made from extruded aluminium and shall have a blade seal on one side of the blade. Frame shall be C channel, 80mm deep with 30mm flanges

Each blade shall be supported on both side with polycarbonate gears with in the frame.

Constructional Details	
Frame Material	Extruded Aluminium
Frame Material Thickness	1.5mm
Frame Type	C- Channel – 80mm deep with 30mm Flanges
Blade Material	Extruded Aluminium
Blade Width	75mm
Blade Type	Airfoil , with seal on one side
Linkage	Polycarbonate Gears

Dimensional Limitations	
Single Section	Multiple Section
1200mm H x 900mm W (Maximum)	2400mm H x 1800mm W (Maximum)
100mm H x 150mm W (Minimum)	

8. COMBINED MOTORIZED FIRE & SMOKE DAMPERS (UL LISTED & UL STAMPED) CLASS 1 LEAKAGE (UL555 RATED FOR 2 HRS (120MIN.) & UL555S LEAKAGE RATING CLASS 1

a. Combined motorized fire & smoke damper shall be UL listed & UL marked as per UL555'S' leakage Class 1.
b. It shall be a multi blade combination fire & smoke damper with Aerofoil design with seal and double skin.
c. It is to be designed for closure of the HVAC duct opening in fire & smoke situations both.
d. It is to be designed to work under elevated temperature conditions of 250°C for 2 hrs.
e. It should be suitable for installation in both horizontal & vertical situations.
f. It's construction details shall be as follows:

Construction Details	
Frame Material	Galvanized Steel
Frame Material Thickness	16G GI
Frame Type	Hat Channel – 123mm wide
Blade Material	Galvanized Steel
Blade Material Thickness	16G GI
Blade Type	Aerofoil with seal, Double Skin
Linkage	Concealed in Frame
Axle Bearing	SS 316
Axle Material	Plated Steel
Jamb Seals	Stainless Steel – Flexible Metal Compression Type (SS-304)
Blade Seal	Silicone
Resettable Thermal Release Device + Open Close Switch (RTR+OCS)	Resettable Thermal Device operates at 74°C (165°F)
Actuator	UL Classified Actuator (24V Standard / 230V Standard)
Sleeves	Factory Fitted: Maximum 432mm long, 20G , 180 GSM Galvanized Steel Sheet(1mm thick sheet)

Dimensional Limitations	
Single Section 1220mm (H) x 914mm (W) (Maximum) 152mm (H) x 203mm (W) (Maximum)	**Multiple Section** 1371mm (H) x 1828mm (W) (Maximum)

Maximum Operational Ratings	
Description	Model FSD-B-U
UL 555S Leakage Rating	Class-1
UL 555 Fire Rating	2 Hrs.
Maximum Velocity	2000 fpm
Maximum Pressure	4 in. WG

g. Fire & Smoke damper shall have blade configuration to ensure maximum free and minimum pressure drop. Damper Blades shall be of double skin 180 GSM galvanized sheet of 14G thickness Aerofoil with

seal and double skin construction. The blades shall be arranged in parallel to provide positive shut off. Each Blade shall have axles supported on both sides with sintered bronze self-lubricating bearings turning in an extruded hole in the frame. All Blades shall be interconnected using linkage concealed within the depth of Hat Channels.

Jamb seals shall be stainless steel flexible metal compression type. Blade seals & blade stop seals shall be UL listed silicone rubber gaskets.

Each damper shall be supplied with a UL approved factory mounted 24 volts or 230 volt spring return actuator as specified in the BOQ. Actuator shall be selected to meet the torque requirements of the damper according to its size. Each Fire & Smoke Damper shall be equipped with a resettable thermal release device to allow controlled closure of damper through the actuator. The thermal release device should be rated 165°F (74°C) and should disconnect electric supply to the actuator in the event of the Fire or Smoke single. The fire & smoke damper should be able to close upon receiving a signal from the Fire & smoke detection panel. Remote indication of Blade Position should be made through an open close switch (OCS) (BMS compatible).

Each damper shall be supplied with a factory mounted sleeve made from minimum 20G(1mm thick) 180GSM galvanized sheet of minimum 432mm length. Silicon sealant shall be applied to the joint between the frame and sleeve to avoid air and smoke leakage.

Damper sizes greater than UL approved single section size shall be supplied in multi module configuration.

All supply and return air ducts at AHU room crossings, at all floor crossings & at supply & return air duct crossing from one fire zone to another fire zone shall be provided with Motor operated combined Fire & smoke damper of at least 120 minutes rating as per latest edition of UL555 'S leakage class 1. These shall be of multi-leaf type and provided with Spring Return electrical actuator. Actuator shall have Form fit type of mounting, metal enclosure and guaranteed long life span. Fire & smoke damper shall be AMCA certified for performance. It shall meet latest edition of AMCA standard 500-D.

Each damper shall be provided with its own control panel, mounted on the wall and suitable for 230 VAC supply. This control panel shall be suitable for spring return actuator and shall have atleast 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.

It shall be HVAC Contractor's responsibility to co-ordinate with the Fire Alarm System Contractor for correctly hooking up the Motor Operated Damper to Fire Detection / Fire Management System. All necessary materials for hooking up shall be supplied and installed by HVAC Contractor under close co-ordination with the fire protection system contractor.

HVAC Contractor shall demonstrate the testing of all Dampers and its control panel after necessary hook up with the fire protection / fire management system is carried out by energizing all the smoke detectors with the help of smoke.

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

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

Fire/smoke damper shall be provided with factory fitted sleeves; however, access doors shall be provided in the ducts within AHU room in accordance with the manufacturer's recommendations.

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

9. UL LISTED FUSIBLE LINK FIRE DAMPER WITH UL LISTED & UL MARKED FUSIBLE LINK:

Fusible link fire damper shall be multi blade fire damper with Aerofoil design with seal and double skin.

Fire Damper shall be UL555 listed & marked.

Fusible link multi blade fire damper shall be UL 555 classified Fusible Link Fire Damper and shall have a 120 minutes fire rating under static conditions. It shall have a failsafe design which shall enable the fire damper to automatically assume the closed position when the duct temperature reaches the design temperature of the fusible link. The frame of the damper shall be constructed with reinforced corners. Low profile Slim line frame in head and sil are to be used in sizes less than 425mm high. Blades shall be reinforced with longitudinal structurally designed aerofoil with seal with Double Skin design.

The construction details shall be as follows:

Construction Details	
Frame Material	Galvanized Steel
Frame Material Thickness	16G GI
Frame Type	Hat Channel – 123mm wide
Blade Material	Galvanized Steel
Blade Material Thickness	16G GI
Blade Type	Aerofoil with seal, Double Skin
Linkage	Concealed in Frame
Axle Bearing	SS 316
Axle Material	Plated Steel
Temperature Release Device	UL Stamped Fusible Link 74°C (Std) (165°F)
Sleeves	Factory Fitted: Maximum 508mm long, Galvanized Steel, 20G thick(1mm thick)

Dimensional Limitations	
Single Section 914mm (H) x 914mm (W) (Maximum) 150mm (H) x 300mm (W) (Maximum)	Larger sizes may be supplied as separate individual dampers for field assembly.

10. FIXED BAR LINER GRILLES / CONTINUOUS LINER GRILLS -- EXTRUDED ALUMINIUM GRILLES FOR SUPPLY & RETURN AIR

a. Supply & return air liner grilles shall be manufactured from high quality extruded Aluminium in powder coated finish, of approved colour & shade.
b. Liner grilles shall be mechanically joined extruded aluminium frame (1mm thick) with fixed bar louvers.
c. Liner grilles shall have:

- Top, bottom & side borders (Flanges shall be 19.5mm)

- Fixed bar louver.
- Only horizontal bar louver parallel to longer dimension
- Frontal louver thickness 5 mm, Rear louver thickness 1 mm
- Louver spacing/blade pitch 13 mm C/C.
- Options of degrees of deflection of louvers:
  a. 0° deflection
  b. 15° deflection one way
  c. 15° deflection two way
- Option of height:
  a. 50mm
  b. 100mm
  c. 150mm
  d. 200mm
  e. 250mm
  f. 300mm
- Fixing arrangement shall be concealed type or screw –thru or tension clip as per site requirement.
- Black or white vertical spacers, as approved.

d. Supply air portion of grille collars shall have opposed blade anodised black matt finish 18G, 50mm deep, extruded aluminium section volume control collar damper, key operated type.

11. DOUBLE DEFLECTION EXTRUDED ALUMINIUM CONSTRUCTION ADJUSTABLE BLADES GRILLES FOR SUPPLY AIR & EXHAUST / RETURN AIR

- The double deflection adjustable blade grilles shall be constructed from high quality Aluminium alloy extrusions with Cleated & Mitred flanges. Grilles shall be in Epoxy polyester powder coated finish of approved colour & shade.
- Blades shall be held in position with stainless steel spring wire.
- Blades shall be individually adjustable, upto 45° deflection.
- The grille shall have 2 Sets of blades. Front set being horizontal & rear set being vertical, both adjustable.
- Fixing arrangement : Concealed type
- Blade pitch: 19mm / 20mm

Note: Supply air & exhaust / return air grilles shall have Extruded Aluminium section, 18G, 50mm deep anodized black matt finish opposed blade volume control collar dampers, key operated (as asked for in the BOQ.)

12. SINGLE DEFLECTION EXTRUDED ALUMINIUM CONSTRUCTION FIXED BLADES 0° DEFLECTION GRILLES FOR SUPPLY AIR & EXHAUST / RETURN AIR

- The single deflection fixed blade grilles shall be constructed from high quality Aluminium alloy extrusions with Cleated & Mitred flanges. Grilles shall be in Epoxy polyester powder coated finish of approved colour & shade.
- Blades shall be held in position with stainless steel spring wire.
- The grille shall have 1 Set of blades. Only horizontal louver.
- Fixing arrangement: concealed type
- Blade pitch: 19mm / 20mm

Note: Supply air & exhaust / return air grilles shall have Extruded Aluminium section, 18G, 50mm deep anodized black matt finish opposed blade volume control collar dampers, key operated (as asked for in the BOQ.)

13. SLOT DIFFUSERS:

a. Supply & Return air slot diffusers shall be constructed of high quality extruded Aluminium in powder coated finish of approved colour & shade. .
b. Various air patterns shall be achieveably by air pattern controlling deflectors, which shall be black matt finish.
c. Supply air slots shall have sliding type Hit & Miss dampers in GI construction with black matt finish.

d. Supply air slots shall have factory fabricated 22G Aluminium plenum with factory acoustic lining of mineral fibre. Plenum shall have factory fitted spigot connectors.

e. Slot diffusers shall be available in:
- 1 to 8 slots design.
- 25mm each slot gap option.
- 20mm each slot gap option.

Note: For hospital / healthcare, critical applications like ICU's / OT's, Procedure Rooms / Treatment Areas / IPD's, Plenums shall not be lined.

14. DIFFUSERS & JET NOZZLES:

a. CIRCULAR / ROUND MULTI-CONE DIFFUSERS:

Circular / Round Diffusers shall be fabricated out of spun Aluminium sheet, single piece construction of outer & inner rings and of powder coated finish of approved colour & shade, in one piece, joint less construction.

It shall be of removable inner core type. The diffusers shall be flush type or anti smudge pattern as may be required. It shall have multi concentric cones in different sizes at an average pitch of 38mm. It shall deliver air in 360° pattern.

It shall have 2 flap Aluminium construction butterfly volume control damper, which shall be key operated from front. Damper blade shall be of 18G & sleeve / casing shall of 20G Aluminium.

b. SQUARE / RECTANGULAR MULTI-CONE DIFFUSERS:

- Square diffusers shall be fabricated out of heavy duty Aluminium sheet die pressed single piece, inner & outer rings and of powder coated finish of approved colour & shade, in one piece, joint less construction. Inner core shall be removable type.
  It shall have heavy duty 18G Extruded Aluminium construction key operated opposed blade volume control damper for front operation. Diffusers frame material shall be 18G Extruded Aluminium (Flat Type) and blade material shall be 0.9mm removable core (Aluminium sheet core)

  Diffuser shall have 4 way air deflection pattern. Diffuser shall be flat flange flush type or anti-smudge type as may be required.
- Rectangular diffuser shall be fabricated out of Extruded Aluminium outer & inner rings with inner removable core arrangement. Diffuser shall be of powder coated finish of approved colour & shade.
  It shall have heavy duty Extruded Aluminium construction key operated opposed blade volume control damper for front operation.

c. **GRID CEILING (600 x 600 GRID CEILING) TYPE MULTI-CONE SQURE DIFFUSERS WITH FACTORY FABRICATED ACOUSTICALLY LINED PLENUM:**

Grid ceiling type diffusers are fabricated out of heavy duty one piece joint less high grade Aluminium sheet. Inner core shall be of removeable type. It shall be powder coated finish of approved colour & shade. The diffuser shall have 4 way air deflection pattern.

It shall have heavy duty 18G Extruded Aluminium construction key operated opposed blade volume control damper for front operation. Diffusers frame material shall be 18G Extruded Aluminium (Flat Type) and blade material shall be 0.9mm removable core (Aluminium sheet core)

Supply air Grid ceiling diffusers shall be with heavy duty 22G Aluminium factory fabricated acoustically lined plenum with spigot for flexible ducts connection.

Note: For hospital / healthcare, critical applications like ICU's / OT's, Procedure Rooms / Treatment Areas / IPD's, Plenums shall not be lined.

d. **GRID CEILING (600 x 600 GRID CEILING) TYPE SQURE PLAQUE TYPE DIFFUSERS WITH FACTORY FABRICATED ACOUSTICALLY LINED PLENUM:**

Grid ceiling Plaque type diffuser shall be fabricated out of heavy duty aluminium sheet of high grade. It shall be of one piece joint less construction.

Inner core shall be of removeable type.

It shall be of powder coated finish of approved colour & shade. It shall have 4 way air deflection pattern.

Supply Air Grid Ceiling diffuser shall be with heavy duty 22G Aluminium factory fabricated acoustically lined plenum with spigot for flexible ducts connection.

It shall have heavy duty 18G Extruded Aluminium construction key operated opposed blade volume control damper for front operation.

Note: For hospital / healthcare, critical applications like ICU's / OT's ,Procedure Rooms / Treatment Areas / IPD's, Plenums shall not be lined.

e. **GRID CEILING (600 x 600 GRID CEILING) TYPE SQURE PERFORATED DIFFUSERS:**
Grid ceiling type perforated diffusers shall be fabricated out of One piece perforated Aluminium face plate, removable with 4 Nos. spring loaded mechanism. The frame shall be constructed from Aluminium. It shall have powder coated finish of approved colour & shade. The diffuser shall have 4 way fixed air pattern deflectors.

The diffuser shall have removeable core. It shall have heavy duty 18G Extruded Aluminium key operated opposed blade volume control damper.

Supply air grid ceiling diffuser shall be with heavy duty 22G Aluminium factory fabricated acoustically lined plenum with spigot for flexible ducts connection.

Note: For hospital / healthcare, critical applications like ICU's / OT's, Procedure Rooms / Treatment Areas / IPD's, Plenums shall not be lined.

f. **EYE BALL JET NOZZLE:**
Eye ball nozzle shall be fabricated out of Aluminium spinnings supported on the flange assembly which can be fixed to the duct collar and with powder coated finish of approved colour & shade. The ball can be rotated in any direction. Nozzle shall be rotatable ± 40° for eye ball jet direction.

18G GSS heavy duty 2 blade butterfly damper, key operated shall be used for volume control.

g. **JET NOZZLE:**
Jet nozzle shall be fabricated out of Aluminium spinnings with powder coated finish of approved colour and shade. The nozzle shall be supported on the flange / ring assembly which can be fixed to the duct collar. The ball shaped part is rotatory inside the ring. It shall have two main part i.e. ball shaped diffuser & the installation ring.
Nozzle shall be rotatable ± 35° for eye ball jet direction.
18G GSS heavy duty 2 flap butterfly damper, key operated shall be used for volume control.

h. **MULTI CONE JET DIFFUSER / REVERSIBLE JET NOZZLE:**
It shall be manufactured from high grade Aluminium spinning supported on a studding & spacer assembly with step up ring placement. The pivoted core can rotate by 360° with respect to the outer casing.

The diffusers shall be suitable for both diffusion & air jet with revisable & rotatable core design. It shall be of powder coated finish of approved colour & shade.

Duct mounted diffusers, shall have 18G, GSS heavy duty 2 flap butterfly damper, key operated for volume control.

i. **DRUM JET DIFFUSER:**
Drum jet diffuser & frame shall be constructed from Aluminium extrusions of frame & inner section with low friction air tight seal strips. Drum jet diffusers shall be of powder coated finish of approved colour & shade. The drum & deflection louvers / vanes shall be adjustable to give full panoramic spread with directional control. These diffusers shall have a feature of both reversible & rotatable core design. The pivot core can rotate by 360°.
Diffusers shall have heavy duty 18G, GSS opposed blade volume control damper.
These diffusers can be used as jet diffuser setting or jet nozzle setting.

15. FRESH AIR INTAKE LOUVERS WITH BIRD SCREEN & VOLUME CONTROL DAMPER
The fresh air intake louvers at least 50mm deep will be made of powder coated extruded

aluminum construction. Bird / insect screen will be provided with the intake louvers. The blades shall be inclined at 45 degree on a 40mm blade pitch to minimize water ingress. The lowest blade of the assembly shall be extended out slightly to facilitate disposal of rain water without falling on door / wall on which it is mounted. Bird screen shall MS powder coated.

The intake louvers shall be provided with volume control dampers in aluminium construction of powder coating or anodized finish as approved. The dampers shall be opposed blade type. The Frame & blades shall be of aluminium construction. The blades shall be of aero foil design. The thickness of damper frame shall be 1.6 mm thick. The damper shall be complete with lever, linkages, shaft nylon bush etc. The damper may be manual/motorized operated as called for in the schedule of quantities. Details of volume control damper's specifications are mentioned in Aluminium construction volume control dampers sub head / items earlier in this section.

Note: Exhaust air louvers shall also be of same specifications as supply air.

16. EXHAUST AIR CIRCULAR VALVE FOR TOILETS / PANTRY EXHAUST

1. Exhaust air valves shall be of rotating disc type to regulate the flow of exhaust.
2. Exhaust air valves shall be of following materials and as asked for in the schedule of quantities:
   - MS sheet with powder coating of approved colour & shade.
   - Die pressed single piece aluminium sheet.
   - Un-breakable poly propylene type.
3. The adjustable central disc can be moved in and out to result in air flow passage area adjustments.
4. The valve shall have a sturdy lock strip to allow screw movement of central disc with lock nuts on both side to hold movement of disc in any desired position. It should be easily connected to a flexible duct.

17. BACK DRAFT DAMPER / GRAVITY LOUVERS:

The BDD shall be made with galvanized steel with:

Frame:	18G Galvanized steel C-channel, 150mm wide with 30mm flange.
Blades:	22G Galvanized steel, 125mm width.
Linkages:	One side frame.
Axles:	½" Plated steel square rod.
Bearings:	Nylon bush.
Min. Size:	152mm W x 152mm (W).
Max. Size:	Single Section: 1219mm (W) x 2438mm (H). Multi Section: 2438mm (W) x 2438mm (H).

18. SOUND ATTENUATORS

Attenuators shall be provided in ducts in accordance with acceptable noise level criteria & if specified in BOQ. Attenuators shall be constructed from high quality pre-galvanized steel sheet casings with lock formed joints along the casing length. Angle iron cross jointing flanges shall be fitted to silencer casings, drilled as required and finished with red oxide primer paint. Acoustic splitters shall be formed by chancel section pre-galvanized sheet steel framework retaining acoustic fill of a density to attain the required performance. Splitters shall have round Nos.,e ends to give smooth entry and exit conditions to minimize air pressure drops. The acoustic fill shall be protected from the air flow by 22 swg minimum perforated galvanized sheet steel. All attenuators shall be selected against a maximum allowable air pressure drop of 100 Pa or less.

It will be the responsibility of the AC Contractor at the time of placing orders for fan equipment to obtain from the manufacturers, certified sound power levels to enable the selected duct silencers to be checked against the original design information, prior to orders being placed.

19. DOCUMENTATION & MEASUREMENTS FOR DUCTING

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

a) Bill of material/Packing list for every duct section supplied.
Measurement sheet covering each fabricated duct piece showing dimensions and external surface area

along with summary of external surface area of duct gauge-wise.

Each and every duct piece to have a tag number, which should correspond to the serial number, assigned to it in the measurement sheet. The above system will ensure speedy and proper site measurement and verification.
Unless otherwise specified, measurements for ducting for the project shall be on the basis of centerline measurements described herewith ductwork shall be measured on the basis of external surface area of ducts. Duct measurements shall be taken before application of the insulation. The external surface area shall be calculated by measuring the perimeter comprising overall width and depth, including the corner joints, in the center of each duct section, multiplying with the overall length from flange face to flange face of each duct section and adding up areas of all duct sections. Plenums shall also be measured in a similar manner.

For tapered rectangular ducts, the average width and depth shall be considered for perimeter, whereas for tapered circular ducts, the diameter of the section midway between large and small diameter shall be adopted, the length of tapered duct section shall be the centerline distance between the flanges of the duct section.

For special pieces like bends, tees, reducers, branches and collars, mode of measurement shall be identical to that described above using the length along the centerline.

The quoted unit rate for external surface of ducts shall include all wastage allowances, flanges and gaskets for joints, nuts and bolts, hangers and angles with double nuts for supports, rubber strip 5mm thick between duct and support, vibration isolator suspension where specified or required, 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.

b. Special Items for Air Distribution shall be measured by the cross-section area perpendicular to air flow, as identified herewith:

i. 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.

ii. 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.

iii. Linear diffusers - shall be measured bycross-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.

iv. 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.

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.

vi. Kitchen Hoods - shall be measured by their cross sectional area at the capture point of fumes, parallel to the surface of kitchen equipment. Quoted rates shall include the grease filters, provision for hood light, suspension arrangement for the hood, profile to direct the air to ventilation ducts and provision for removable drip tray.

20. TESTING AND BALANCING

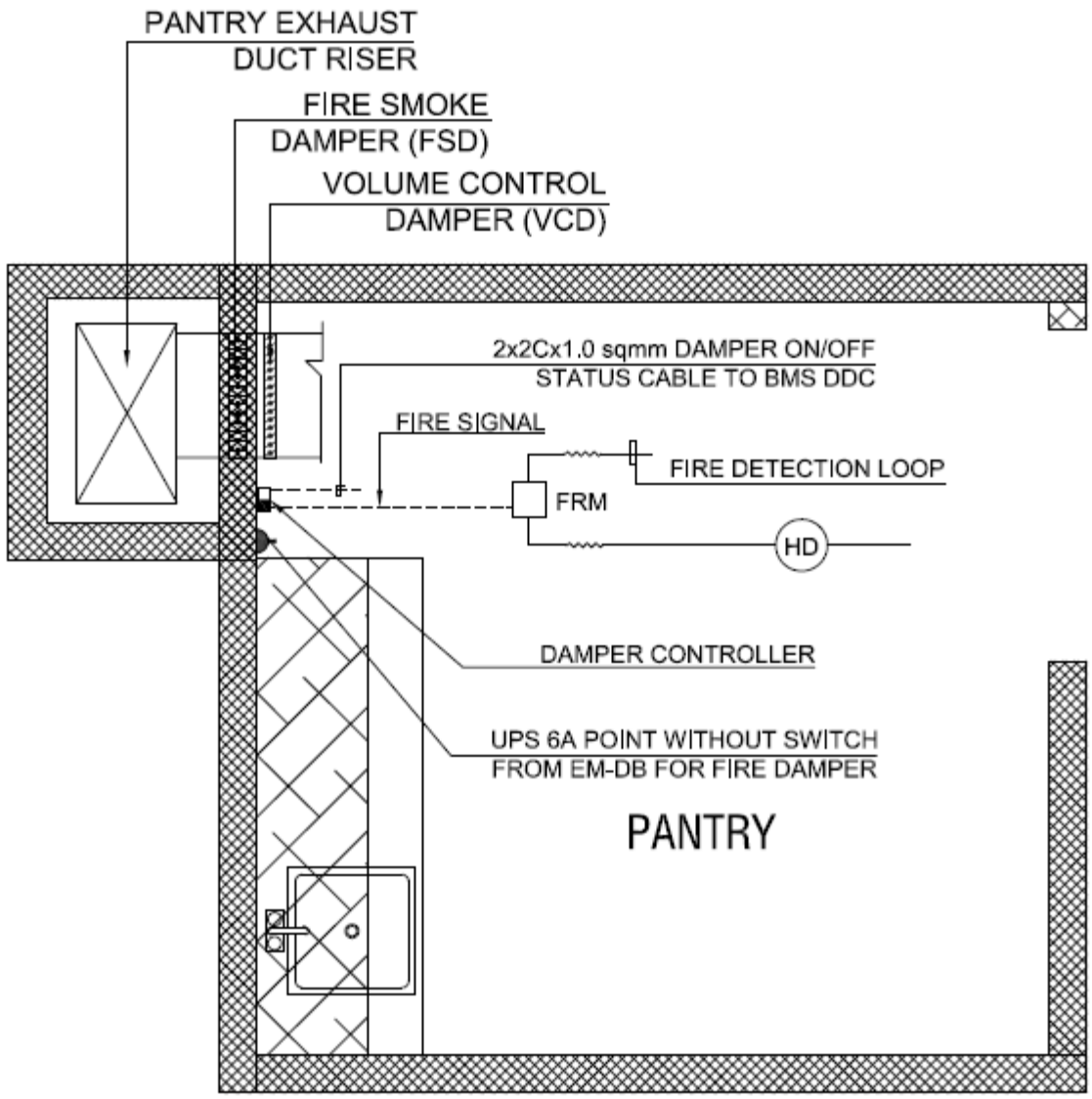
After the installation of the entire air distribution system is completed in all respects, all ducts shall be tested for air leaks by visual inspection.

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

report shall be provided with completion documents.

Note: Colour, shades, finish of all grilles, diffusers and dampers shall be gotten approved by the architect, before ordering & supply of products. Samples of each item need to be submitted & approval sought from architect.

PROVISION AND WIRING DETAILS FOR FIRE DAMPERS, MOTORIZED DAMPERS AND AHU'S FOR TRIPPING / OPERATION LINKED WITH FIRE DETECTION SYSTEM AND BMS



TYPICAL PANTRY / KITCHEN ON FLOOR

NOTES ;

HVAC Drawings / Tender to show:

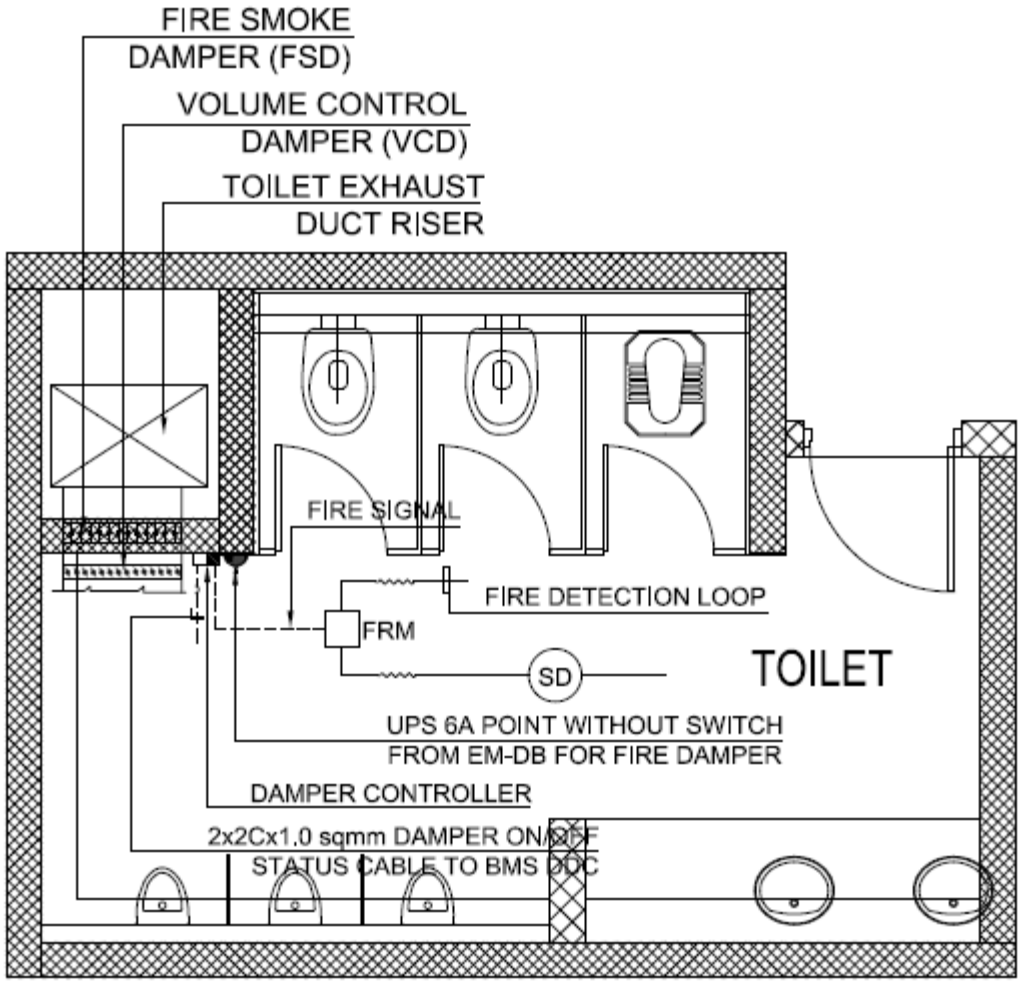
- One VCD & Motorised FSD at floor tap-off.

Electrical Drawings / Tender to show:

- One UPS '6A' point without switch from EM-DB for each FSD.

FDA Drawings / LV Tender to show:

- One FRM (Fire Relay Module) near fire damper (FSD).
- Include 2C x 1.5 Sq.mm Armoured Fire Survival cable of 1.5 M length from FRM to FSD controller as fire signal.



TYPICAL TOILET ON FLOOR

NOTES :

HVAC Drawings / Tender to show:

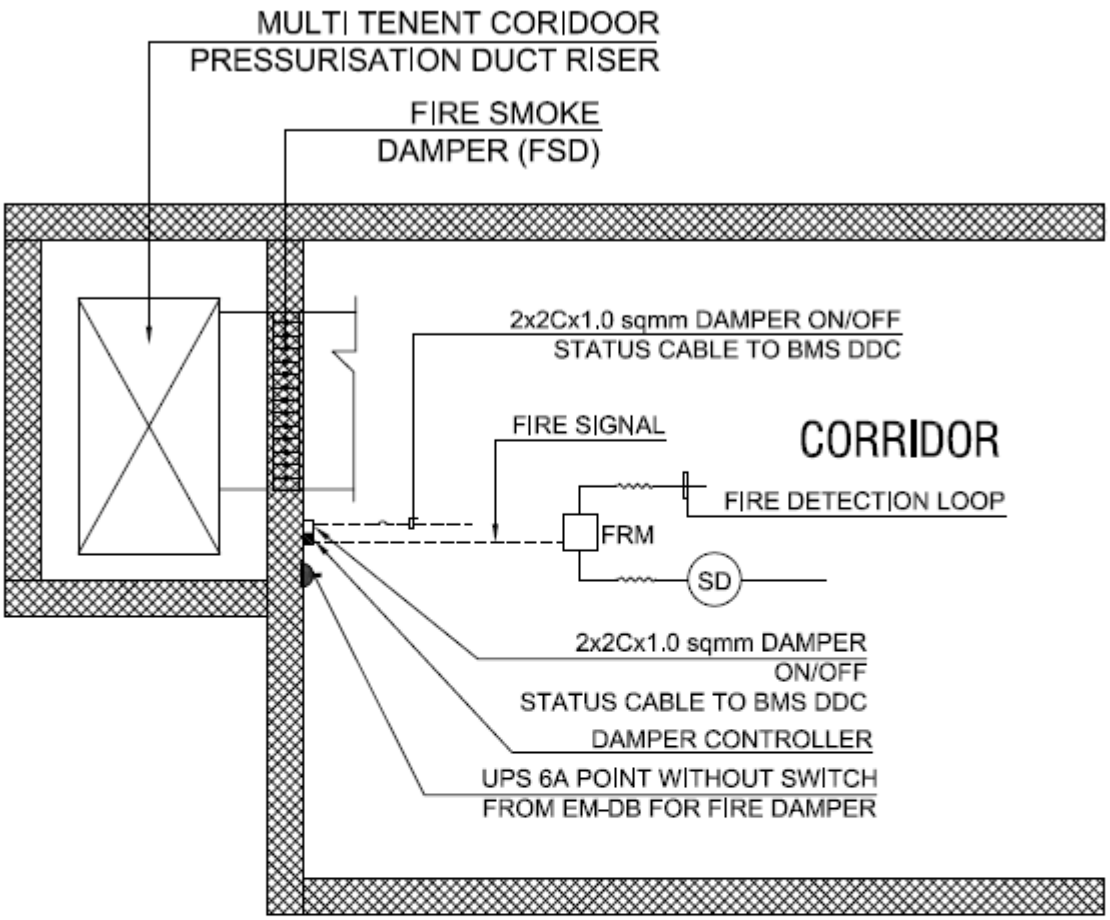
- One VCD & Motorised FSD at floor tap-off.

Electrical Drawings / Tender to show:

- One UPS '6A' point without switch from EM-DB for each FSD.

FDA Drawings / LV Tender to show:

- One FRM (Fire Relay Module) near fire damper (FSD).
- Include 2C x 1.5 Sq.mm Armoured Fire Survival cable of 1.5 M length from FRM to FSD controller as fire signal.



TYPICAL MULTI TENENT CORIDOOR PRESSURISATION

NOTES :

HVAC Drawings / Tender to show:

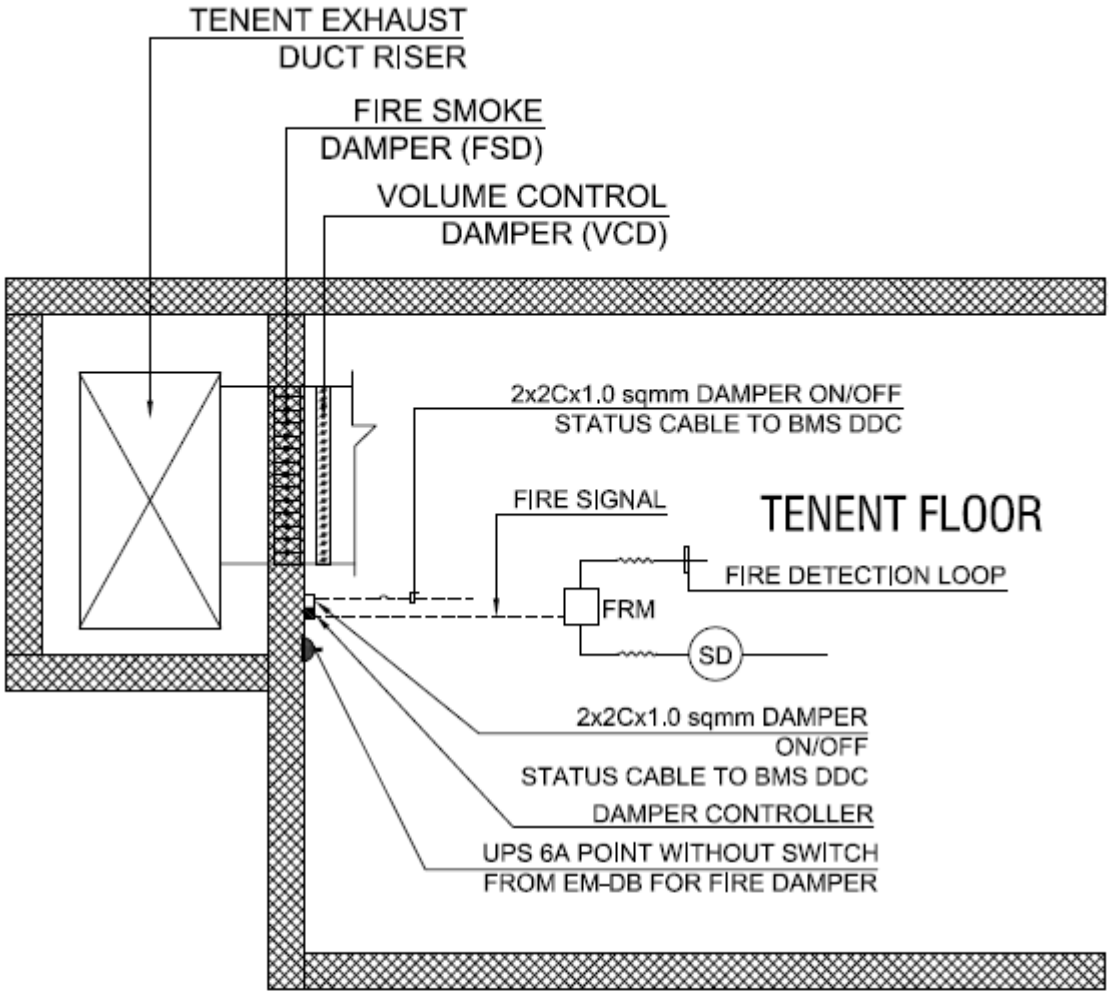
- Motorised FSD at floor tap-off.

Electrical Drawings / Tender to show:

- One UPS '6A' point without switch from EM-DB for each FSD.

FDA Drawings / LV Tender to show:

- One FRM (Fire Relay Module) near fire damper (FSD).
- Include 2C x 1.5 Sq.mm Armoured Fire Survival cable of 1.5 M length from FRM to FSD controller as fire signal.



TYPICAL DUCT TENENT EXHAUST

NOTES :

HVAC Drawings / Tender to show:

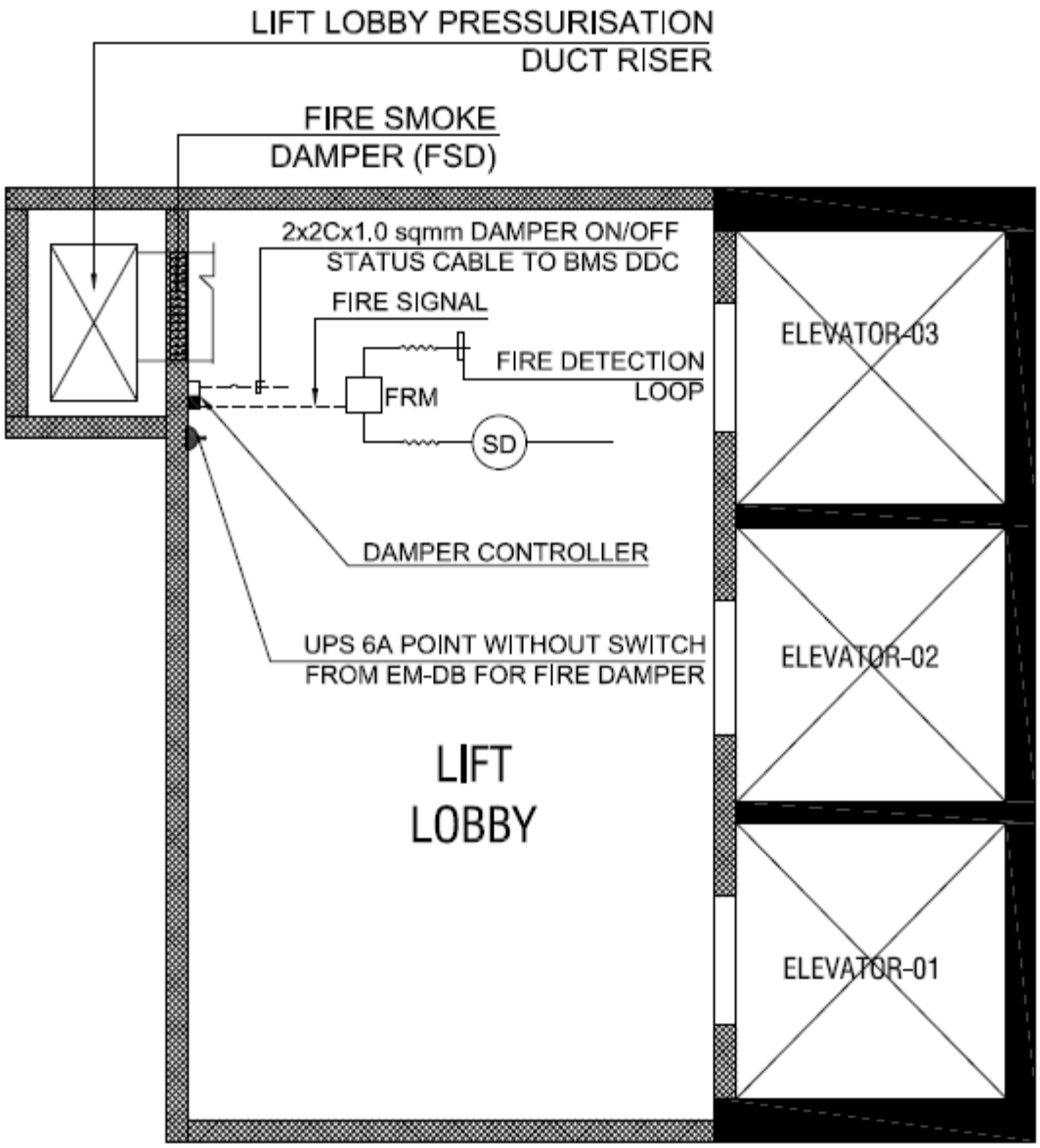
- One VCD & Motorised FSD at floor tap-off.

Electrical Drawings / Tender to show:

- One UPS '6A' point without switch from EM-DB for each FSD.

FDA Drawings / LV Tender to show:

- One FRM (Fire Relay Module) near fire damper (FSD).
- Include 2C x 1.5 Sq.mm Armoured Fire Survival cable of 1.5 M length from FRM to FSD controller as fire signal.



TYPICAL LIFT LOBBY PRESSURISATION DUCT ON FLOOR

NOTES :

HVAC Drawings / Tender to show:

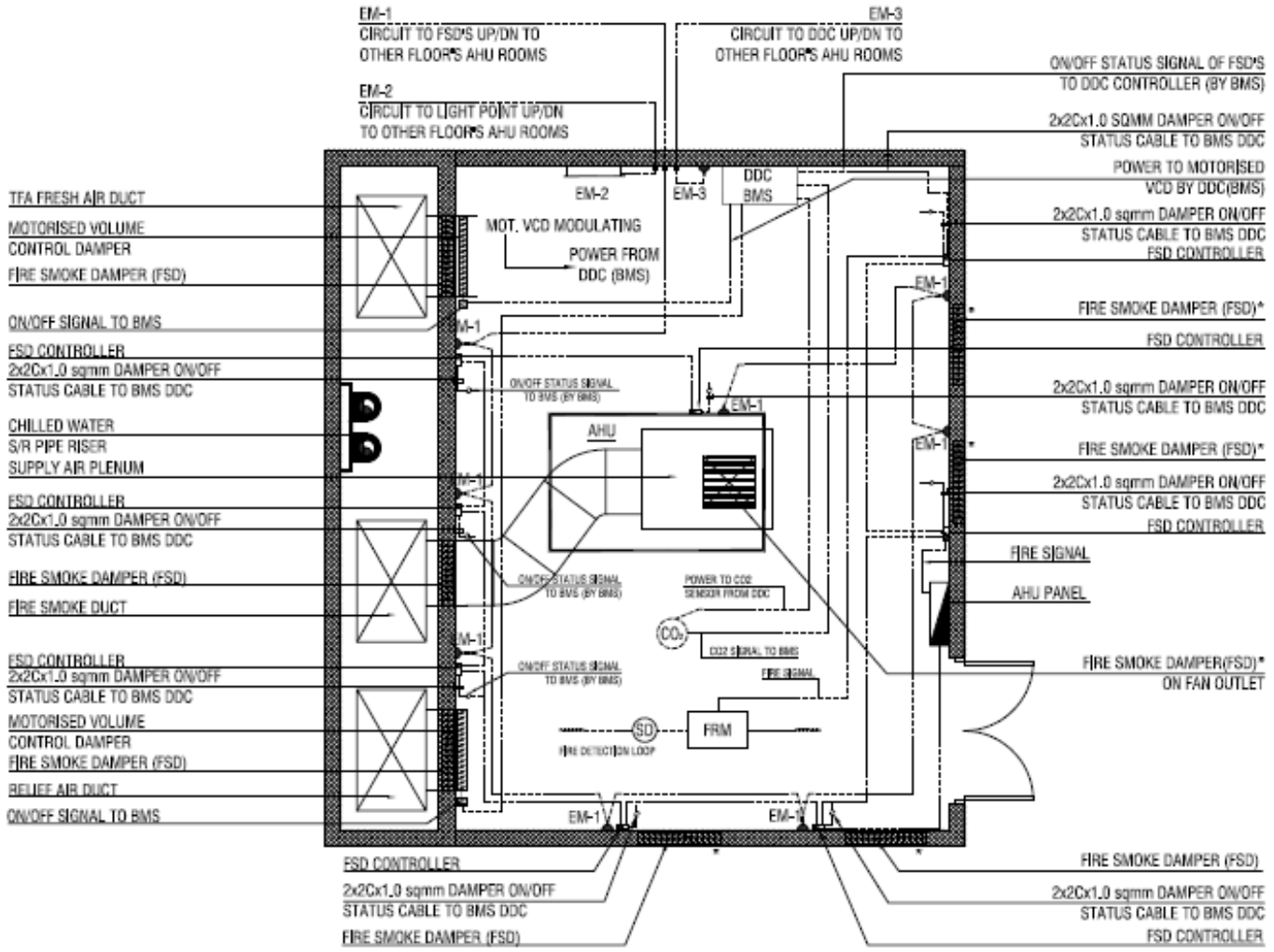
- Motorised FSD at floor tap-off.

Electrical Drawings / Tender to show:

- One UPS '6A' point without switch from EM-DB for each FSD.

FDA Drawings / LV Tender to show:

- One FRM (Fire Relay Module) near fire damper (FSD).
- Include 2C x 1.5 Sq.mm Armoured Fire Survival cable of 1.5 M length from FRM to FSD controller as fire signal.



TYPICAL AHU ROOM DETAIL

NOTES :

PROVISIONS:

HVAC:

Provide FSD's in:

- TFA duct floor tee-off.
- Smoke Exhaust duct floor tee-off.
- Relief air duct tee-off.
- AHU supply & return air duct. *
- AHU Outlet tee-off. *

Provide Motorized VCD inc

- TFA duct floor tee-off.
- Relief Air duct floor tee-off.
- Provide 2C x 1.5 Sq.mm armoured fire survival cable loop-on - loop-out from first FSD controller to last and to AHU VFD / Starter.

ELECTRICAL:

- Provide 6A UPS point without switch from EM-DB for each FSD.

FDA & LV:

- Provide smoke detector / multi detector in AHU room.
- Provide one FRM (Fire Relay Module).
- Provide 2C x 1.5 Sq.mm Copper Conductor Armoured fire survival cable from FRM to first FSD controller, say 2 M per AHU room.

* AHU SUPPLY AND RETURN AIR DAMPERS MAY BE BY TENENT AS PART OF INTERIOR FITOUT

SUBHEAD-P. VARIABLE REFRIGERANT VOLUME SYSTEM (VRV)

1. GENERAL

The air-conditioning system shall exhibit 'Capacity control' operating features providing very efficient energy and maximum comfort to the users. The VRV system shall be air-cooled, variable refrigerant system consisting of modular outdoor units and multiple indoor units, each heaving capability to cool independently and serving the different requirements of the room and users.

2. SCOPE

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

3. TYPE

Units shall be air cooled, variable refrigerant volume air conditioner consisting of one outdoor unit and multiple indoor units. Each indoor units having capability to cool or heat independently for the requirement of the specified area/ rooms.

It shall be possible to connect minimum 10 indoor units on one refrigerant circuit. The indoor units on any circuit can be of different type and also controlled individually. Following type of indoor units shall be connected to the system:

Ceiling mounted cassette type (Multi flow)
Ceiling mounted Ductable type
Wall mounted type

Compressor installed in outdoor unit shall be equipped with all inverter compressor.The system shall be capable of changing the rotating speed of inverter compressor by inverter controller to follow variations in cooling and heating load.

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

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

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

4. OUTDOOR UNIT

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

All outdoor units shall have minimum two scroll compressors and be able to operate even in case one of compressor is out of order.
In case of outdoor units above 16HP, the outdoor unit shall have at least 2 inverter compressor so that the operation in not disrupted with failure of any compressor.
It shall also be provided with duty cycling for multiple inverter compressor switching starting sequence of multiple outdoor units.

The outdoor unit shall be modular in design and should be allowed for side by side installation.

The unit shall be provided with its own microprocessor control panel.

The outdoor units shall have anti-corrosion paint.

The outdoor unit shall be fitted with low noise, aero spiral design fan with grill for spiral discharge airflow to reduce pressure loss and should be fitted with DC fan motor to better efficiency. The ductable unit shall be capable to deliver 40mm external static pressure to meet long duct connection requirement.

The condensing unit shall be designed to operate safely when connected to multiple fan coil units.

5. COMPRESSOR

The compressor shall be highly efficient scroll type and capable of inverter control. It shall change the speed in accordance to the variation in cooling or heating load requirement:

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 stock. Forced lubrication shall also be employed.

Oil heater shall be provided in the compressor casing.

6. HEAT EXCHANGE

The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to from a cross fin coal.

The aluminum fins shall be covered with anti-corrosion resin film.

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

7. REFRIGERANT CIRCUIT

The refrigerant circuit shall include liquid (refrigerant – R-22/R-407c/ R-134a) & gas shut-off valves and a solenoid valves at condenser end.

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

8. OIL RECOVERY SYSTEM

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

This section deals with supply, installation, testing, commissioning of various type of indoor units confirming to general specification and suitable for the duty selected. The type, capacity and size of indoor units shall be as specified in detailed Schedule of Quantities.

9. GENERAL FOR INDOOR UNITS:

Indoor units shall be either ceiling mounted cassette type, or ceiling mounted ductable type or wall mounted type as specified in Schedule of Quantities. These units shall have electronic control valve to control refrigerant flow rate respond to lead variations of the rooms.

The address of the indoor unit shall be set automatically in case of individual and group control.

In case of centralized control, it shall be set be liquid crystal remote controller.

The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.

The cooling coil shall be made out of seamless copper tubes and have continuous aluminium fins. The fins shall be spaced be collars forming and integral part. The tubes shall be staggered in the direction of airflow.

The tubes shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fans. Each coil shall be factory tested at 21kg/sqm air pressure under water.

Unit shall have cleanable type synthetic non woven type filter fixed to an integrally moulded plastic frame. The filter shall be slide away type and neatly inserted.

Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.

Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the through its touch screen, icon display and color LCD display.

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

Starting/ stopping of Air conditioners as a zone or group or individual unit.

Temperature settling for each indoor unit or zone.
Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/ disabling of individual remote controller operation.

Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

Display of air conditioner operation history.

Daily management automation through yearly schedule function with possibility of various schedules.
The controller shall have wide screen user friendly color LCD display and can be wired by a non polar 2 wire transmission cable to a distance of 1 km. away fro indoor unit.

10. HEAT RECLAIM VENTILATION UNIT:

In order to achieve the purpose of better indoor air quality, the Heat Reclaim ventilation (HRV) unit must exchange the heat between supplied fresh air and exhausted air in order to bring the outside air closer to indoor temperature and humidity conditions. Thus it must recover the thermal energy of exhaust air and reuse it for supplied fresh air. This must lead to ventilation without increasing the load and thus saving in running cost.

It shall be possible to interlock this HRV system with operation of VRV system to simplify installation and improving the efficiency of air-conditioning.

The casing of the HRV unit shall be made of galvanized steel plate, insulation with self extinguishable polyurethance foam. The must have air filters of multo directional fibrous fleeces type.
The heat exchange element must be designed without any moving parts for higher durability and reliability, it should have high permeability high efficiency specially processed paper which is flame retardant and fungi proof to keep air clean.

The unit must be provided with built-in multidirectional fibrous filter.

The unit must have optimized design of fan and air flow passage to make it compact and supply air & exhaust air passage must be arranged in such pattern so as to prevent mixing of supply (fresh) and exhaust air.

The unit must be suitable for single phase supply and have their control panel.

Latest malfunction code for easy maintenance. The controller shall have self-diagnostic feature for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flat individually as per requirement.

11. CEILING MOUNTED CASSETTE TYPE UNIT (MULTI FLOW TYPE):

The unit shall be ceiling mounted type. The unit shall include synthetic non-woven type filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight and shall be able to suspend from four corners.

Unit shall have an external attractive panel for supply and return air. Unit shall have one-way/ two-way/ four-way supply air grillers on sides and return air grille in centre.

Each unit shall have high lift drain pump, fresh air intake provision, Low gas detection system and sound level shall be less than 38 db at 1.5 mtr. Distance.

All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view. It should have provision of connecting branch ducts.

12. CEILING MOUNTED DUCTABLE TYPE UNIT:

Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan sections & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for Ductable arrangement.

13. CEILING SUSPENDED TYPE:
Unit shall be suitable for ceiling suspended arrangement below false ceiling. The unit include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

14. HIGH WALL MOUNTED UNITS:
The units shall be wall-mounted type. The unit includes pre filter, fan section & DX coil section. The housing for unit shall be light weight powder coated galvanized steel.

Unit shall have an attractive external casing for supply and return air.

15. FLOOR STANDING TYPE:
Unit shall be suitable for floor standing arrangement. The unit includes pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

Centralized Type Remote (Touch Screen Type) Controller

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

The Graphic Controller must act as an advanced air conditioning management system to give complete control of VRV air conditioning equipment, it shall be have ease of use for the user.

GALGOTIAS UNIVERSITY

SUBHEAD-Q. LT CABLES - 1.1 KV GRADE & CABLE TRAYS

1. GENERAL

The cables shall be supplied, inspected, laid, tested and commissioned in accordance with drawings, Specifications, relevant Indian Standard and cable manufacturer's instruction.

2. MATERIAL

2.1 XLPE INSULATED, FRLS(H) PVC SHEATHED (IS: 7098 PART-1) CABLES

Specification of 1.1KV grade Single / Multicore XLPE insulated, **FRLS(H)** PVC sheathed Aluminium / Copper conductor Armoured / Unarmoured cables shall be as per IS: 7098 Part-1:

i. Conductor:

- Material : Aluminium / Copper : Electrolytic grade
- Shape : Aluminium conductor : 6 & 10 sqmm. Solid circular
  : 16 sqmm. & above stranded compacted shaped
  : Copper conductor : 4 & 6 sqmm. stranded non compacted circular
  : 10 sqmm. stranded compacted circular
  : 16 sqmm. & above stranded compacted shaped

ii. Insulation Material : Cross linked polyethylene XLPE (Red, Yellow, Blue & Black)

iii. Inner Sheath : Extruded inner FRLS(H) PVC sheath type ST-2.

iv. Armouring : Single layer of galvanized steel round wires / flat strips.

v. Outer sheath : FRLS(H) PVC Sheath type ST-2.

vi. Colour of sheath : Black.

Note: Single core armoured cables shall be with "Non-magnetic" type armouring.

2.2 PVC INSULATED, FRLS(H) PVC SHEATHED (IS:1554) CABLES

Specification of 1.1KV grade Single / Multicore PVC insulated, PVC sheathed Copper conductor Armoured / Unarmoured cables shall be as per IS: 1554:

i. Conductor:

- Material : Copper : Electrolytic grade
- Shape : Copper conductor : 1.5, 2.5, 4 & 6 sqmm. stranded non compacted circular
  : 10 sqmm. stranded compacted circular

ii. Insulation Material : PVC (Red, Yellow, Blue & Black)

iii. Inner Sheath : Extruded inner FRLS(H) PVC sheath type ST-1.

iv. Armouring : Single layer of galvanized steel round wires / flat strips / Non-magnetic armouring for single core cables.

v. Outer sheath : FRLS(H) PVC Sheath type ST-1.

vi. Colour of sheath : Black.

Note: Single core armoured cables shall be with "Non-magnetic" type armouring.

3. FIRE SURVIVAL CABLES(CIRCUIT INTEGRITY CABLES)

i. Voltage Grade: Up to 1000 V

ii. Designed as per : BS 7846

iii. Cable Size: Up to 1 to 4 Cores, 1.5 sq. mm. to 400 Sq.mm. copper.

iv. Conductor Type: Stranded Circular Copper.

v. Construction: Class 2

vi. Insulation Material: Glass Mica tape as flame barrier + XLPE Insulation

vii. Sheathing Material: Special Low Smoke Zero Halogen Compound

viii. Armour: Galvanized Steel

ix. Colour Codes: As per customer's requirement

x. Fire test as per : BS 8491/ BS 8434-2/ BS EN 50200 , CWZ tests (all three tests on one cable)

xi. Low Smoke Emission: Light Transmittance > 60 % as per IEC 61034

xii. Flame Retardant: As per IEC 60332

xiii. Halogen Free: Acid Gas Less than 0.5 % as per IEC 60754

xiv. Min. Bending Radius: 12 x O.D.
xv. Suitable for 950°C for 3 hrs duty operation.

Fire Survival / Resistance circuit integrity armoured cable of 600/1000V rated with Copper Circular conductors having Glass Mica (Fire barrier) tape covered by crosslinked poly Ethylene insulation (XLPE) and LSZH as inner & outer sheaths. Basic design as per BS 7846 for copper cables, Should retain circuit integrity as per Category-3 of BS:8419 when tested in accordance to BS 8491 for power cables having overall diameter of 20mm and above & BS EN 50200 PH-120 for control cables having overall diameter less than 20mm. Type test reports of each lot from 3rd party inspection agency required prior to despatch. (Should be LPCB /TUV/BRE-Global certificate to be submitted)

The cables should meet circuit integrity at 1000 volts with simultaneous action of Fire, Impact & water on single sample when tested in accordance to BS 8491 & BS EN 50200 PH-120.

The cables should not emit toxic gases in case of fire. The toxicity index should be less than 3 (refer NES 713).

The cables should comply with the requirements of IEC-61034 Part 1&2 (Measurement of Smoke density of cables burning under defined conditions).

The cables should comply with the requirements of BS EN 60754 (Determination for amount of halogen acid gas content which shall not be greater than 0.5%)

Fire & type test reports of each lot from 3rd party inspection agency required prior to despatch.

3A. APPLICATION OF FIRE SURVIVAL CABLES

Note: Contractor to use such cables as specified in the application table for all the application listed in the table irrespective of the fact if the same cables are not shown seperately in the BOQ of cable / in the electrical SLD. Contractor to ensure this point and bring it to the notice of PMC / Client / Consultant if any deviation in the BOQ and SLD is found.

ANNEX A

(Foreword)

APPLICATION OF FS CABLE

Sl No.	System Description	Cable Fire Rating Required (°C)	Time for which System Should Withstand (Minutes)
(1)	(2)	(3)	(4)
i)	Fire pumps	FS (950/FWS)	180
ii)	Pressurization	FS (950/FWS)	180
iii)	Smoke venting including its ancillary systems, such as dampers and actuators	950	60
iv)	Fire fighting shaft (staircase, lift, lift lobby)	FS (950/FWS)	180
v)	Fireman's lifts (including all lifts)	FS (950/FWS)	180
vi)	Exit signage lighting	950	120
vii)	Emergency lighting	950	120
viii)	Fire alarm system		
	a) Conventional (zone based system)	650	60
	b) Intelligent addressable system	650	60
ix)	Public address (PA)system (related to emergency voice evacuation and annunciation)	650	60
x)	Magnetic door hold open devices	650	60
xi)	Lighting in fire command centre and security room	FS (950/FWS)	180

3.5 Fire Survival Categories — Following categories of fire survival cable shall be applicable:

a)	*Resistance to fire alone*	950 °C for 3 h	Symbol F
b)	*Resistance to fire and water*	650 °C for 15 min followed by 5 bursts for water	Symbol W
c)	*Resistance to fire and mechanical shock*	950 °C for 15 min along with 03 mechanical impact	Symbol S
d)	*Resistance to fire, water and shock*	Category F3/ F30/F60/F120 as below	Symbol FWS

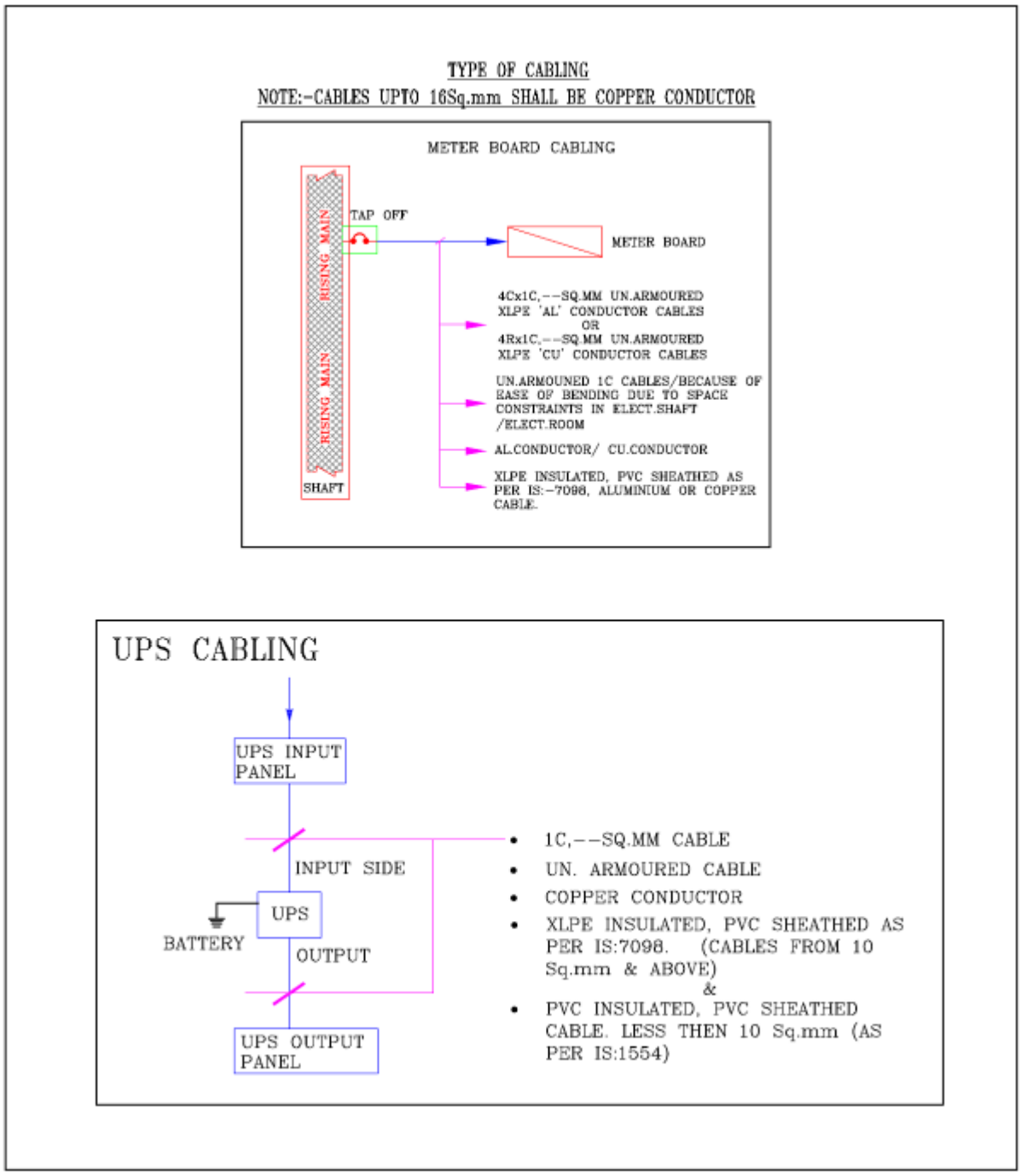
Category F 3: Resistance to fire, resistance to fire with water, resistance to fire with mechanical shock, assessed separately when tested in accordance to **E-7.3**, **E-7.4** and **E-7.5** respectively.

Category F 30: Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance to Annex E for 30 min

Category F60: Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance to Annex E for 60 min

Category F120: Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance to Annex E for 120 min

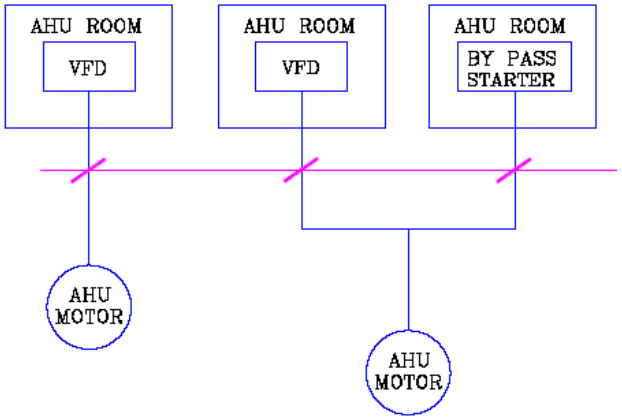
4. TYPE OF CABLES TO BE USED FOR DIFFERENT APPLICATIONS



TYPE OF CABLING

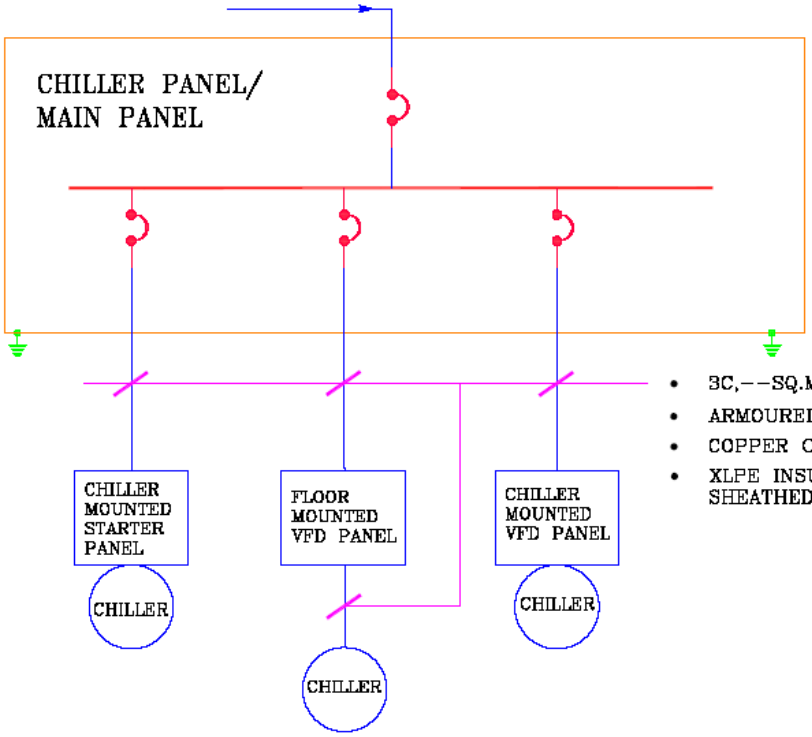
NOTE:-CABLES UPTO 16Sq.mm SHALL BE COPPER CONDUCTOR

AHU CABLING



- 3C,--SQ.MM CABLE
- ARMOURED CABLE
- COPPER CONDUCTOR
- XLPE INSULATED, PVC SHEATHED AS PER IS:-7098

CHILLER'S CABLING



- 3C,--SQ.MM CABLE
- ARMOURED CABLE
- COPPER CONDUCTOR
- XLPE INSULATED, PVC SHEATHED AS PER IS:-7098

5. CABLE LAYING AND HANDLING

It should be ensured that both ends of the cable are properly sealed to prevent ingress absorption of moisture.

6. CABLE HANDLING

When cable drums have to be moved over short distance, they should be rolled in the direction of the arrow marked on the drum. While removing cables, the drums shall be properly mounted on jacks or on a cable wheels or any other suitable means, making sure the spindle, jack etc. are strong enough to take the weight of the drum.

The cables shall not be given a sharp bend to a small radius. The minimum safe bending radius for all types of PVC/XLPE cables shall be taken as 12 times the overall diameter of the cable. Wherever practicable, larger radius should be adopted. At joints and terminations, the bending radius of individual cores of a multicore cable shall not be less than 15 times its overall diameter. Cable with kinks and straightened kinks, or with similar apparent defects like defective armoring etc. shall not be installed / laid.

Cables of different voltages as well as power and control cables should be kept in different trenches/racks with adequate separation. Where available space is restricted, LV/MV cable shall be laid above HV cables.

Where cables cross over cannot be avoided, the cable of higher voltage shall be laid at a lower level than the cable of lower voltage.

Installation of cables including jointing shall be carried out as per IS: 1255 amended and revised to date.Power and communication cables shall, as far as possible cross at right angles. Where power cables are laid in proximity to communication cables, the horizontal and vertical clearances shall not normally be less than 60 cm.

Cables shall be laid direct in ground, in pipes / closed ducts, in open ducts or on surface depending on environmental conditions, and as required in schedule of quantities.

During the preliminary stages of laying the cable, consideration should be given to proper location of the joint position so that when the cable is actually laid, the joints are made in the most suitable places and as approved by Consultant. As far as possible, water logged locations, carriage ways, pavements, proximity to telephone cables, gas or water mains, inaccessible places, ducts, pipes, racks, etc. shall be avoided.

The cable shall not in any circumstances be bent so as to form an abrupt right angle but must be rounded off at the corners to a radius not less than 12 times the overall diameter of the cable.

In case, where there are chances of any damage to the wiring/cables, such wiring/cables shall be covered with a sheet metal protective covering (not less than 16 SWG), the base of the covering being flush with the plaster or brickwork as the case may be, or the wiring /cables shall be drawn through a heavy gauge metal conduit pipe by complying with all the requirements of conduit wiring system.

Such protective covering shall, in all cases, be fitted on all down drops within 1.5 m from the floor or from floor level upto the switch board, whichever is less.

While cutting and stripping of the outer sheathing of the cable, care shall be taken that the sharp edge of the cutting instrument does not touch the inner insulation of the conductors. The protective outer covering of the cable shall be stripped off near connecting terminal and this

protective covering shall be maintained upto close proximity of connecting terminals. The cables laid near junction boxes shall be made moisture proof with a plastic compound.

7. CABLE JOINTING & TERMINATION

Jointing shall be as per the manufacturer's recommendations using standard kits. Cable joints shall be made in suitable, approved cable joint boxes, jointing of cables in the joint boxes and filling of compound shall be done as per manufacturer's recommendations. Heat shrinkable joints shall be made.

Cables shall be terminated onto the terminals of switchgear through crimping lugs of proper size and of heavy duty. Cable lugs shall be fitted onto the cable by crimping or compression jointing.

Continuity of cable armouring is to be maintained. Double compression glands to be used. Proper crimping tools to be used.

7a. CABLE GLANDS:

Heavy duty Brass-Nickel plated Double compression glands to be employed for cable termination into the panels & boards.

See photos of glands as below:

i. Single compression gland, IP-68 rated, shall be used for flexible un-armoured copper cables.
ii. Double compression glands, weatherproof IP-67 rated, shall be used for all the armoured / un-armoured cables.
iii. Double compression flame proof glands, IP-66 rated, shall be used for fire rated / fire survival cables.

7b. CABLE LUGS & THIMBLES:

Heavy duty lugs & thimbles to be employed for making cable & wire connections.

- Aluminium cables connection with aluminium bus bars shall be made with aluminium lugs / thimbles.
- Copper cables / copper wire connections with copper bus bars or with tinned copper witch gear terminations or with silver plated switchgear terminals shall be made with tinned copper lugs / thimbles.
- Copper cables / copper wire connections with aluminium bus bars shall be made with tinned copper lugs / thimbles or with bi-metal lugs / thimbles i.e. aluminium alloy lugs / thimbles with copper plating & then tinning.
- Hardware for cabling connections to panel's bus bars, to switch gear, to DB's and motors etc.: High tensile MS Alloy grade 8.8, Zinc coated (minimum 10microns coating). (Trivalent Plating CR3+).

Bolts, nuts & washers for cabling connections shall be:

1.	Steel Hardware		
	Salt mist spray withstand	:	120 Hours
	Bolt and nuts		
	Hardware quality	:	8.8
	According to	:	EN 20898, EN ISO 3506-1, 4759-1 (=S=FT30860)
	Contact Washers		
	Washer quality	:	8.8
	Class	:	160 HV
	According to	:	EN 20898, EN ISO 3506-1, 4759-1

Note : double washers to be employed. (plain and spring washers).

8. TRENCHING & CABLE LAYING

The minimum width of trench shall be 45 cm and depth shall be 75cm for laying of cable. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the minimum gap between the cables is one diameter of the cable unless specified otherwise. The clearance between axis of the end cables and the sides of the trench shall be minimum 1.5 D (diameter) of the end cable. The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided. Where gradients and changes in depth are unavoidable, these shall be gradual. The bottom of the trenches shall be level and free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 9 cm in depth. Cable laid in trenches in a single tier formation shall have a covering of clean, dry sand of not less than 20 cms. above the base cushion of sand before the protective cover is laid.

In the case of vertical multi-tier formation, after the first cable has been laid, a sand cushion of 30 cms shall be provided over the initial bed before second tier is laid. If additional tiers are formed, each of the subsequent tiers shall have a sand cushion of 30 cms as stated above. The top-most cable shall have final sand covering not less than 17 cms before the protective cover is laid.

Unless otherwise specified, the cables shall be protected by second class bricks of not less than 20 cm x 10 cm x 10 cm (nominal size) as per CPWD building specification, or protection covers placed on top of the sand, (brick to be laid breadth wise) for the full length of the cable to satisfaction of the owner. Where more than one cable is to be laid in the same trench, this

protective covering shall cover all the cables and project at least 5 cm over the sides of and cables.

The trenches shall be then back filled with excavated earth free from stone or other sharp-edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 30 cm. Unless otherwise specified, a crown of earth not less than 50 mm in the center and tapering towards the sides of the trench shall be left to allow for subsidence. The crown of earth, however, should not exceed 10 cms.

Where road bends or lawns have been cut or kerb stones displaced, the same shall be repaired to the satisfaction of the architect and all surplus earth or rock removed to places as specified.

In locations such as road crossing, entry to building in paved areas etc. cables shall be laid in pipes or closed ducts.

All cable entry/exit points into the building through pipe sleeves shall be properly sealed with water and fire safe sealants in an approved manner to avoid any seepage of water into the building.

Manholes of adequate size, as decided by the Architect, shall be provided to facilitate of adequate strength feeding/drawing in of cables and to provide working space for persons. Suitable manhole covers with frame of proper design shall cover Manholes.

CABLE LOOPS: Sufficient cable loop length shall be left at both ends.

9. CABLES ON HANGERS OR RACKS / TRAYS

The contractor shall provide and install all iron hangers racks, or racks with die-cast cleat, with fixing rag bolts or girder clamps or other specialist fixing as required.

Where hangers or racks are to be fixed to wall sides ceiling and other concrete structures, the contractor shall be responsible for cutting away, fixing and grouting in rag bolts and making good the damages as required.

The hangers or racks shall be designed to leave at least 25 mm clearance between the cables and the face to which it fixed. Multiple hangers shall have two or more fixing holes. All cables shall be saddled at not more than 500 mm intervals. These shall be designed to keep provision of some spare capacity for future development. Minimum spacing between the cables shall be one diameter of the cable or as specified.

Cable Clamps , saddles and screws :

Cable fixing clamps, saddles & screws on trays / walls / slabs		Indoor Application: • Aluminium • Readymade type clamps or Made from 20mm x 3mm aluminium sheet / strips. • 8mm SS-304 Screws for cable size 90mm² and above. • 6mm SS-304 Screws for cable size less than 90mm². Outdoor Application: • SS-304 • Clamps Made from 20x1.8mm SS-304 sheet / strips. • 8mm SS-304 Screws for cable size 90mm² and above. • 6mm SS-304 Screws for cable size less than 90mm².
Clamps spacing		• 600mm C/C in vertical fashion in shaft on vertical trays. • 1000mm C/C on horizontal tray or cable racks.

10. TESTING OF CABLES

The Megger value in normal dry weather shall be 50 mega ohm for 1.1 KV grade cable. Cables shall be tested at works for the following tests before being dispatched to site by the project team:

a. Insulation Resistance Test.
b. Continuity resistance test.
c. Sheathing continuity test.
d. Earth test.(in armoured cables)
e. Hi Pot Test.

Test shall also be conducted at site for insulation between phases and between phase and earth for each length of cable, before and after jointing. On completion of cable laying work, the following tests shall be conducted in the presence of the Owner's site representative:

a. Insulation Resistance Test(Sectional and overall)
b. Continuity resistance test.
c. Sheathing continuity test.
d. Earth test.

All tests shall be carried out in accordance with relevant Standard Code of Practice and Electricity Rules. The Contractor shall provide necessary instruments, equipment and labour for conducting the above tests and shall bear all expenses in connection with such tests. All tests shall be carried out in the presence of the PMC / Owner representative.

11. CABLE TAGS

Cable tags shall be made out of 2mm thick aluminum sheets. Each tag shall be 2" in dia or 3" x 3" square with one hole of 2.5mm dia, 6 mm below the periphery, or as approved by Consultant. Cable designations are to be punched with letters / number punches and the tags are to be tied to cables with piano wires of approve quality & size. Tags shall be tied inside the panels beyond the glanding as well as above the glands at cable entries. Along trays tags are to be tied at all bends. On straight lengths, tags shall be provided at every 5 meters.

Cables shall be secured to cable trays with 3mm thick x 25mm wide aluminum strips/suitable GI clamp, or as approved by Consultant, at 1000 mm intervals and screwed by means of rust proof screws, washers and bolts, of adequate but not excessive lengths. Cable trays for horizontal runs suspended from the ceiling will be supported with mild steel straps or brackets, at 1000 mm intervals and the overall tray arrangement shall be of a rigid construction. External cabling route marker with GI plate marked with "DANGER 1.1 kV CABLE" with 1 meter long GI angle iron grouting bracket including 1:3:6 ratio cement concrete base block of minimum size 200 x 200 x 350 mm to be provided or as approved by Elect. Supply Company.

12. CABLE TRAY

a) The MS cable trays should have undergone rigorous rust proofing process, which should comprise of alkaline, degreasing, descaling in diluted sulpharic acid and a recognized phosphating process. The sheet work shall then be given two coats of oxide primer before two coats of final painting. Cable trays & tray supports shall be either painted (Stove enameled) pre-galvanized or hot dip galvanized as called for in the schedule of quantities.

b) Cable trays shall be complete with bends, joints, coupler plates and accessories as may be required for joining the cable trays.

c) Cable trays shall be either perforated or ladder type as called for in the schedule of quantities.

13. PERFORATED CABLE TRAYS : Standard Technical details of perforated cable tray shall be as follows:

S. No.	SIZE OF TRAY(Width)	THICKNESS & COLLAR HEIGHT
1.	150mm to 450mm width	2mm thick & 50mm collar
2.	600mm to 750mm width	2mm thick & 50mm collar
3.	900mm to 1200mm width	3mm thick & 50mm collar

Note: Supports shall not be charged extra. It shall be considered to be included in the rate of the tray.

14. LADDER TYPE CABLE TRAYS

Standard technical details of ladder type cable trays shall be as follows:

S. No.	SIZE OF TRAY	SIZE OF MAIN CHANNEL OR RUNNER	SIZE OF RUNG & SPACING	CABLE TRAY SUPPORT
1.	900mm to 1500mm	25 x 100 x 25 x 2.5mm	20 x 50 x 20 x 2.5mm @ 250 C/C	50 x 50x 5mm angle @ 1000mm spacing.
2.	450mm to 750mm	20 x 75 x 20 x 2.0mm	20 x 50 x 20 x 2mm @ 250 C/C	40 x 40 x 5mm angle @ 1250mm spacing.
3.	150mm to 300mm	20 x 75 x 20 x 2.0mm	15 x 35 x 15 x 2mm @ 250 C/C	40 x 40 x 3mm angle @ 1500mm spacing.

Hangers shall be minimum 10mm dia GI Round bar.

Fixing /supporting arrangement shall be as approved by the Consultant / Owner / PMC

Hardware to be used in cable tray system shall be hot dip galvanized.

Note: Supports shall not be charged extra. It shall be considered to be included in the rate of the tray.

All structural steel shall be according to the latest revision of IS: 226 & 808.

a. **Quality of Zinc**
Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS: 209-1992.

b. **Coating Requirement**
Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square meter shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs; rust stains bulky white deposits, blisters. Mild steel flats / wires shall undergo a process of degreasing, pickling in acid, cold rinsing and then galvanizing.

15. CABLE TRAY SUPPORT / INSTALLATION SYSTEM:

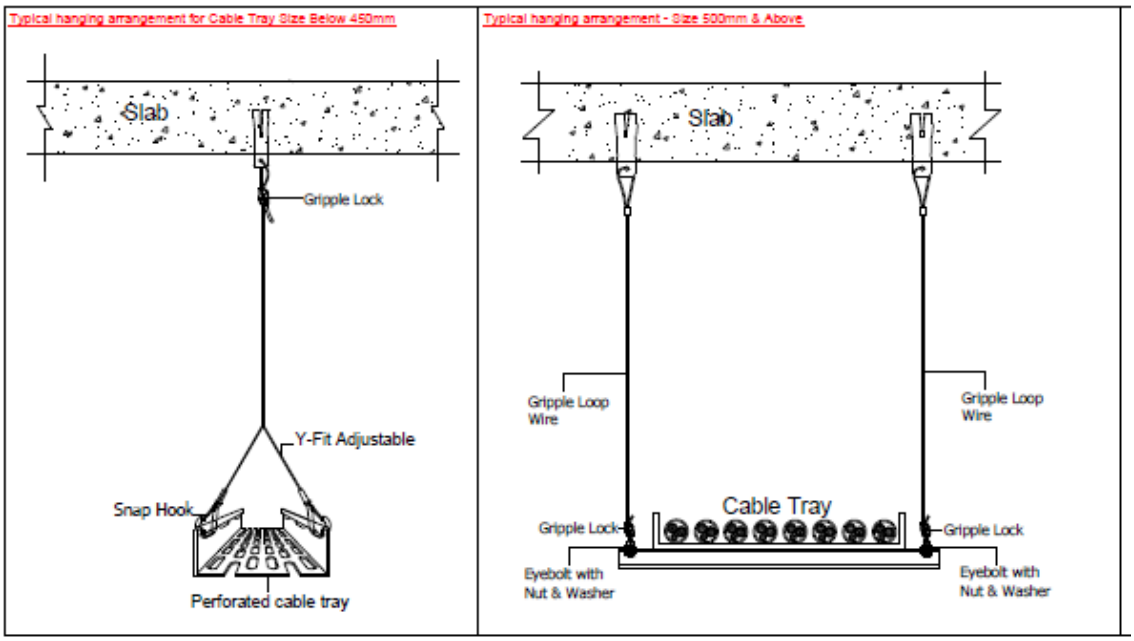
15.1 FACTORY FABRICATED MODULAR SUPPORTING SYSTEM:

a. Cable tray support from RCC Slab/PEB Structure:
Wire Hangers shall be used to suspend all static Electrical services.
Wire Hangers should consist of a pre-formed wire rope sling with a range of end fixings to fit various substrates and service fixings, these include a ferruled loop, permanently fixed threaded M6 (or M8, M10,M12) stud/eyebolt, permanently fixed nipple end with toggle, at one end or hook or eyelet, cladding hook, barrel, wedge anchor, eyebolt anchor or any other end fixture type or size as per manufacturers recommendation and design. The end fixings and the wire must be of the same manufacturer with several options available. The system should be secured and tensioned with a Hanger self-locking lock (double channel wedge type lock) at the other end. Once the lock is engaged, for safety purpose, unlocking should only be done by using a separate setting key and should not be an integral part of the self-locking lock. In case unlocking arrangement is an integral part ie. button/pin type, the button/pin shall be hidden under a separate housing cover made of same material as of housing. To guard against accidental unlocking, the unlocking button/pin should be accessible if and only if the housing cover is removed. Only wire and/or supports supplied and/or approved, shall be used with the system.

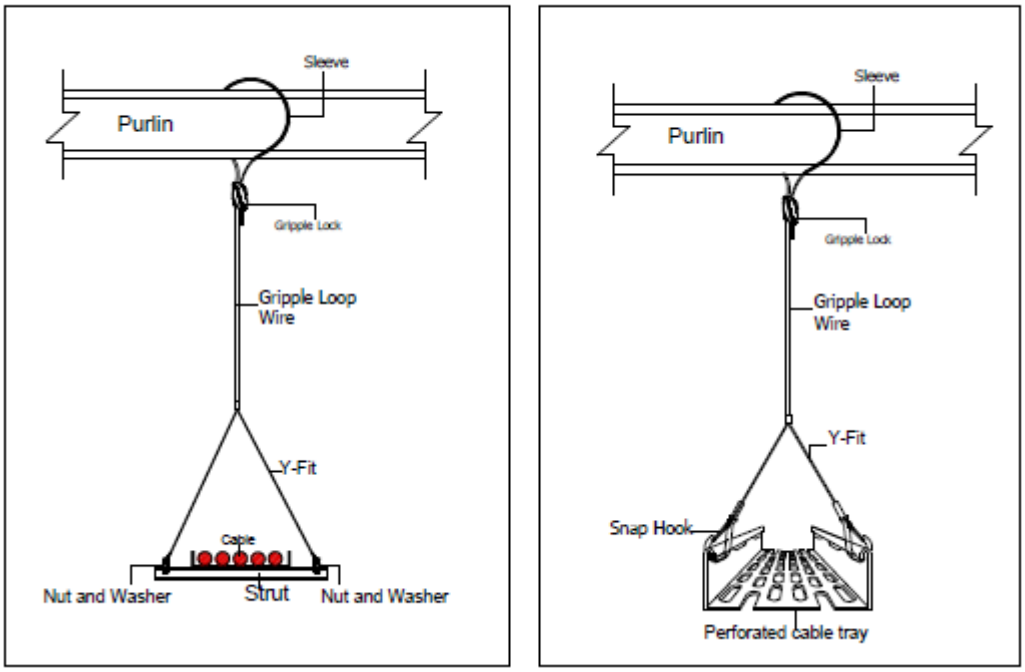
j. Wire Hangers should have been independently tested by Lloyds Register. APAVE, TUV, CSA, ADCAS, Intertek, ECA, UL (Electrical) and SMACNA, approved by CSA and comply with the requirements of DW/144 and BSRIA – wire Rope Suspension systems. Wire rope should be manufactured to BSEN 12385: 2002 standards. UL (Electrical) certificate should be for the complete wire rope hanger (including the wire, lock and end fittings). If product is not certified by SMACNA and manufacturer is giving compliance to SMACNA then the wire dia. Selection shall be as mentioned in SMACNA Chapter 5, Tables 5-1, 5-1M, 5-2 and 5-2M.

- Wire Hangers shall be independently tested by reputed third party testing organization to sustain safe working load for 120min at elevated temperature of 175 deg. C or above.
- The contractor shall select the correct specification of wire hanger to use for supporting each particular service. Each size should be designated with a maximum safe working load limit (which incorporates a 5:1 safety factor).
  The correct specification of wire hanger required should be determined using the following formula or as per manufacturer's recommendation, whichever is stringent.
  Weight per meter of object suspended (kg) X distance between suspension points (m) = weight loading per Hanger suspension point (kg).
  Where the installed wire rope is not vertical then the working load limit shall be reduced in accordance with the recommendations give in the manufacturer's handbook. The contractor shall select the correct length of wire rope required to support the service. No in–line joints should be made in the rope.
  The standard range of Hanger Kits should contain galvanized high tensile steel wire rope or stainless steel wire rope as per the application, the minimum specification is as above and should be manufactured to BS 302, BSEN12385. **Comply with manufacturer's load ratings and recommended installation procedures.** The testing shall be done to the minimum breaking load of the wire thus giving a minimum safety factor of 5: 1.

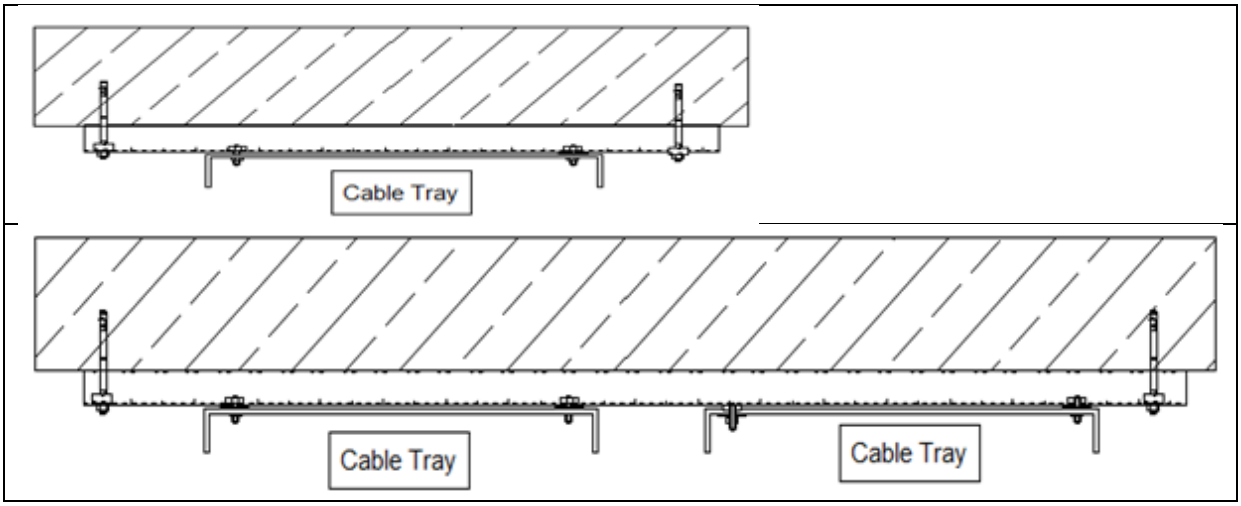
Typical hanging arrangement of Cable Tray for Slab Area



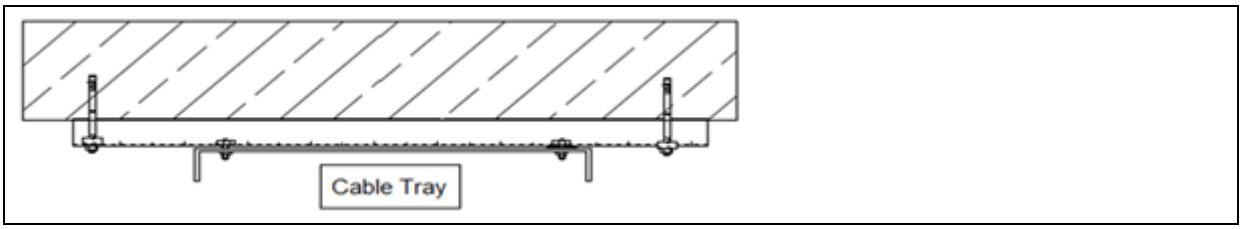
Typical hanging arrangement for Cable Tray Size Below 450mm

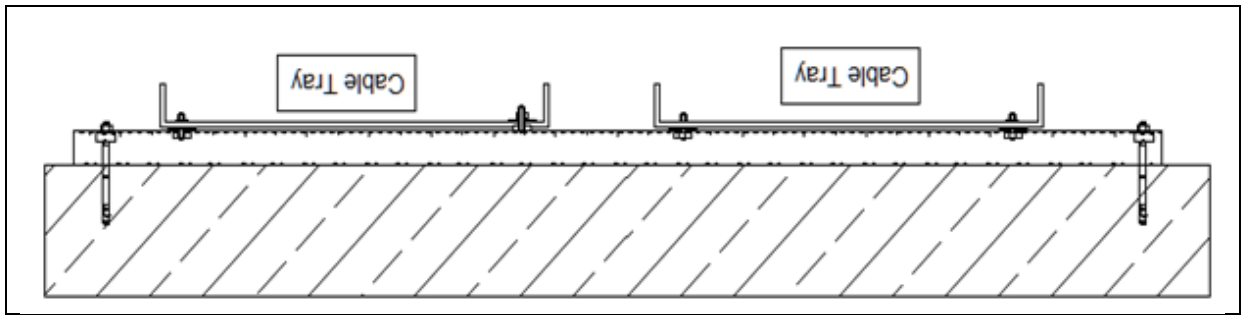


Typical Arrangement for cable tray support from building shaft



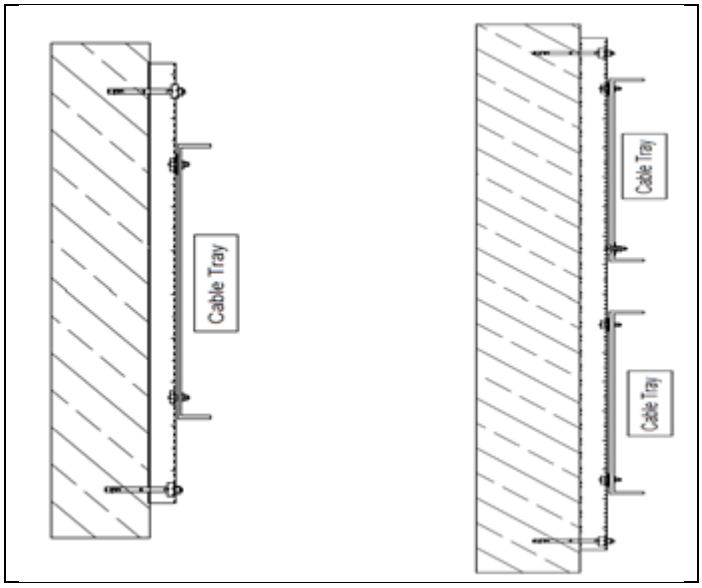
`Typical Arrangement for cable tray support from building terrace





Foot based supports can also be used as an alternative to the above mentioned support system.

Typical Arrangement for Cable tray support from Building shaft



Supports can be provided for: Busbar, Cable Ladder, Cable Tray, Cable Basket, Channel, Trunking, Light Rafts, Luminaires, Secondary Supports, Safety Lines, High Bay/Low Bay Lights, Electrical Cables, CCTV and Catenary Supports: Y-Fit solution shall be used to a maximum width of 500mm Cable Tray. For Tray over 500mm cradle support method or independent supports must be taken as appropriate based on load. Any other solution can be used based on manufacturer's recommendation on site conditions after prior approval.
Special Supports: Refer to manufacturer's recommendations on Catenary supports, special care should be taken with tensioning of the wire and angles at which the installation of services are made**.**
Stainless Steel Supports should be available for food, chemical and High Corrosion areas near coastlines.
Refer to manufacturers catalogue and installation guide for further technical information. **Comply with manufacturer's load ratings and recommended installation procedures.**
The struts/channels used shall be made of pre-galvanized sheet as per IS standards. Contractor shall submit load calculation sheet and stress analysis of all struts/channels, brackets etc which shall be carried out by using a reputed third party modeling/analysis software.

Note: Contractor shall be fully responsible & accountable for the structural stability of the hanging / supporting system of duct work. The above data furnished about supports is only for guidance. The ducting contractor to hire a specialist agency / vendor to design the supporting system of duct work and submit a design & certificate along with supporting marked drawings with typical supporting arrangements.

All the supporting system shall be supplied from same manufacturer. And a structural stability certificate to be issued by the duct installation /HVAC contractor to the client along with the design.

15.2 SEISMIC RESTRAINTS & SEISMIC ISOLATION FOR ELECTRICAL SERVICES & EQUIPMENTS:

15.2.1 INTRODUCTION:

This specification is intended to provide general guidelines for the Seismic Analysis of Non-Structural components ie. MEP & FF distribution & equipments

15.2.2 SCOPE:

Seismic Analysis/Calculations should be carried out based on IS16700:2017. References from IS16700:2017 should be taken for seismic forces. Exceptions for Seismic supports as stated in ASCE7, SMACNA seismic restraint manual should be considered. For Fire-fighting distribution components & equipment sway bracing design and exceptions mentioned in NFPA 13 will supersede exceptions mentioned in ASCE 7.

15.2.3 DESIGN LOADS:

a. DEAD LOADS

The dead load is assessed based on the weight of the equipment/distribution system.

b. SUPERIMPOSED DEAD LOAD

The super imposed dead load is assessed based on the weight of the equipment / distribution system. For pipes containing water, weight of the water filled pipe is included in this load case.

c. EARTHQUAKE LOAD

Earthquake load should be calculated as per IS16700:2017, appropriate references from ASCE 7-10 should be considered considered

As per IS16700:2017/NBC 2016, following parameters should be considered

4. Seismic zone should as per NBC 2106 Part 6 Section 1 or as per building design seismic zone factor.
5. Seismic zone factor, Z – 0.24 (ZONE IV-Delhi NCR Region), as per NBC 2016 Part 6 Section 1 Table 42 Clause 5.3.4.2.
6. Seismic Design Force is calculated as IS16700:2017, as follows

Fp = Z * (1+x/h) (ap * Ip/Rp) Wp ≥ 0.10 Wp (As per IS16700:2017)

where,

Z = seismic zone factor given in NBC 2016 Table 42 (Clause 5.3.4.2) should be considered.

m.) Zone factor for some important towns are given at NBC 2016 Part 6 Section 1 Annexure K or as per building design seismic zone factor = 0.24 (Zone IV)

n.) Response Reduction Factor should be taken as per IS16700:2017.

o.) Amplification factor (as per IS16700:2017)

p.) Importance factor, Ip (as per IS16700:2017)

q.) z - Height in structure of point of attachment of component with respect to the base.

r.) h - Average roof height of structure with respect to the base

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

d. WIND LOAD ANALYSIS:

Calculate static and dynamic loading due to wind forces required to select/design vibration isolators, bases and seismic & wind restraints for outdoor & roof top equipments/services. The calculation of wind load shall be as per IS:875(Part 3)/NBC 2016 Part 6 Section 1. Worst case between Seismic Loads and Wind Loads has to be considered for supporting and vibration isolation.

15.2.4 ANALYSIS METHOD

Linear static analysis is considered for gravity loads. Equivalent static method is considered for Earthquake loads.

15.2.5 DESIGN METHODOLOGY

The supporting structural steel system shall be designed according to Limit state method as specified in IS: 800-2007. Appropriate loads and its combinations, as per relevant clauses in IS codes should be chosen for design. Based on selection location and type of seismic support for the same shall be provided in the shop drawings.

15.2.6 LOAD COMBINATION

The various loads are combined in accordance with the stipulations in NBC2016.
Load combinations considered in design are as follows,

Type	Load Case	Load Details
Primary	1	Dead Load-DL
Primary	2	Superimposed dead Load at Terrace- SIDL
Primary	3	Earthquake Load along X-Direction EQ(+X)
Primary	4	Earthquake Load along Z-Direction EQ(+Z)
Primary	5	Earthquake Load along Y-Direction EQ(+Y)

LOAD FACTOR FOR LOAD AND RESISTANCE FACTORED DESIGN (LRFD):

0.9 DL ± 1.5 (Eqx ± 0.3 Eqy) …… NBC2016 5.3.3.4

15.2.7 MATERIALS:

a. Structural Steel:

Materials	Standards
Hot-Rolled Members	
ISMC Channels	IS:2062
Angles	IS: 2062
Bolts & Nuts	Grade 4.6
Anchor fasteners	Grade 8.8
Cold-Formed Members	IS:811

b. Seismic Wire Rope Kit:

Wire based seismic restraint kits shall consist of Break strength certified, pre-stretched seismic cable with a permanently fixed 45 degree eyelet or ferruled copper/copper plated loop fixed to single, double or retrofit seismic bracket, or any other end fixture type or size as per manufacturers recommendation and design. The end fixing, bracket and wire must be of the same manufacturer. The system should be secured and tensioned with a Seismic rated self-locking grip at the other end. For ease of installation, flexibility, and workmanship only wire based seismic restraint system shall be used to restraint/brace all services.

Wire seismic restraints supplied and/or approved, shall be used with the system, the wire rope should not have color coding applied to it and should only be supplied with separate color coded tags. Bracing elements shall be seismic certified/tested by third party accredited lab as per ASHRAE standard 171, Method of Testing for Rating Seismic and Wind Restraints.

Cables shall have color coded size identifiers as per seismic requirements and must be pre-stretched. Cables shall be suspended 45 degrees (+/- 15 degrees Engineers allowances). Once the grip is locked for safety purpose unlocking should only be done by using a separate setting key and unlocking button should not be an integral part of the self-locking grip for safety purpose.

At the point of the seismic restraint installation, a rigid support is required (threaded rod + rod stiffener or appropriate as approved by a qualified engineer). The location of all the seismic restraint points shall be determined by a qualified engineer.

When attaching the seismic restraints to the slab/structure seismic rated anchor shall be used. The connection of channel/ stiffener to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

The seismic product to be used shall be determined by a qualified engineer, based on data supplied by the manufacturer.

The contractor shall select the seismic bracket for the attachment to the ‘service’ as either a standard or retrofit bracket. All parts and materials shall have been fully tested to conform to local/ state/provincial requirements and codes. The same manufacturer shall supply all parts and materials

The designer/contractor shall select the correct specification of wire based seismic restraints to use for restraining/bracing particular service mentioned in this specification; approved concrete anchors must be used by the designer/contractor. Refer to Table 1 below.

The Seismic engineer shall select the correct length of wire rope required to restrain/brace the various services & applications. No in–line joints should be made in the rope.

Table 1:

Wire based seismic restraint Safe Working Loads	
Kit Type	**Design Strength (LRFD) (kg)**
Type 2	239
Type 3	522
Type 4	1261

All Seismic restraints must comply with manufacturer's load ratings and recommended installation procedures.

c. Threaded Rod:

Size	Threaded Rod Diameter (mm)	Allowable Working Load (kN)	Allowable Working Load (kgs)	Max Unbraced Rod Length (mm) Table 7-5 ASHRAE Seismic Manual
M10	10	2.7	275.23	457
M12	12	5	509.68	635
M 16	16	8	815.5	584
M 20	20	12	1223.24	610
M 22	22	16.7	1702.34	660

d. Rod Stiffeners:

Rod stiffener consisting of steel channel and attachment clips capable of bracing vertical suspension rods or made out of Polypropylene to avoid potential buckling due to vertical compression forces should be used. Braces shall be selected to be of sufficient strength to prevent support rod buckling. Brace shall be attached to the vertical suspension rod by a series of attachment clips.

e. Riser Guides:

Risers shall be restrained against excessive lateral movement during service/earthquake. Riser guides must allow axial motion of the pipe and provide lateral restraint against static, hydrostatic & earthquake loads. The guides should include a neoprene bushing. This bushing allows some flexibility and prevents short-circuiting of vibration isolated device. The neoprene bushing also allows seismic loads to be cushioned and distributed to several guides.

f. Riser Anchors:

Straight solid risers can be rigidly anchored at one point provided the load is not concentrated on one floor. Riser anchors must be able to restraint against static, hydrostatic & earthquake loads. Riser anchor should restraint against excessive movement during services and earthquake thrusts by the use of 3-axis resilient anchors designed to withstand the required installation, operating and earthquake loads. Anchors shall be of steel construction and shall be attached to the riser with either a heavy-duty riser clamp or a welded support bracket in a manner consistent with anticipated design load. Snubbers shall limit lateral and vertical riser movements at each anchor location to a maximum of ¼" (6mm) in any direction. Anchors shall include a minimum of ½" (13mm) thick resilient neoprene pad to cushion any impact and avoid any potential metal-to-metal contact. Anchors shall be capable of withstanding an externally applied force of up to their rated capacity in any direction.

g. Riser Clamps

Riser clamps should be two-piece heavy-duty clamps bolted together and have a load rating based on clamping capacity. Riser clamps reinforce the pipe and distribute forces evenly to minimize pipe wall stress concentrations that would otherwise develop with welded lugs or brackets. The clamp must be sized for two times the dead load and there must be a positive means of engagement between the clamp and riser.

h. All Directional Seismic Restraint Spring Mounts

Spring isolators shall be single or multiple coil spring elements which have all of the characteristics of free-standing coil spring, incorporating lateral and vertically restrained seismic housing assemblies. Restraint housing shall be sized to meet or exceed the force requirements of the application and shall have the capability of accepting coil springs of various sizes, capacities, and deflections as required to meet the required isolation criteria. All spring forces shall be contained within the coil/housing assembly, and the restraint anchoring hardware shall not be exposed to spring generated forces under conditions of no seismic force. Spring element should have built-in levelling adjustment and shall be accessible from above and suitable for use with a conventional, pneumatic or electric impact wrench. Restraint element shall

incorporate a steel housing with elastomeric elements at all dynamic contact points. Elastomeric elements shall be replaceable. Restraint shall allow ¼" (6 mm) free motion in any direction from the neutral position. Isolators should have a min. operating Kx/Ky ratio of 1.0, springs should have 50% additional travel to solid beyond rated load. Isolators should be selected in the range of -30% to +25% of rated load. All isolators certified to withstand minimum 1.0 G force. Seismic 'G' ratings for all seismic restraint products should be 3rd party certified and should be part of relevant submittal. Spring elements should be color-coded for easy field verification and should be capable handling high deflection and should have a low natural frequency.

i. Modular Support Components:

C-channel vertical suspension shall be selected to be of sufficient strength to prevent support buckling. Wire rope brace shall be attached to the connector connecting vertical suspension C-channel/threaded rod/stiffener with horizontal C-channel by a suitable connector capable of taking seismic loads. Stress analysis calculation should be submitted for the worst-case length of the C-Channel/Strut members used. Stress analysis should be done for tensile, compressive and combined stresses.

The connection of wire rope bracing /channel/ threaded rod to the concrete should be done using anchors with ETA C2 approval for seismic loads. The design of anchors should be done as per ETA-TR 045 guidelines for seismic anchor design.

j. Flexible Connections/bellows for accommodation of differential seismic motion:

Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement. Install flexible connectors where adjacent sections or branches are supported/connected by different structural/non-structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural/non-structural element from the one supporting the connections as they approach equipment. All installed bellows and flexible connections shall be designed to accommodate for seismic motion and deflection.

15.2.8 SERVICABILITY REQUIREMENTS:

a. Deflection:

Deflection Limitations shall be as per 5.6.1 Table 6 of IS800:2007

15.2.9 SEISMIC BRACING DESIGN:

Seismic Supporting system shall be analyzed for seismic forces as per IS 16700 Cl. 10.2 and design intent of SMACNA seismic restraint manual - Guidelines for Mechanical system; ASCE 7-10 Chapter 13 and ASHRAE Practical Guide to Seismic Restraint shall be used as a reference for design basis & exceptions. The load calculations, stress calculations, design basis and exceptions considered shall be part of submittal for approval.

a. Project Design Criteria:

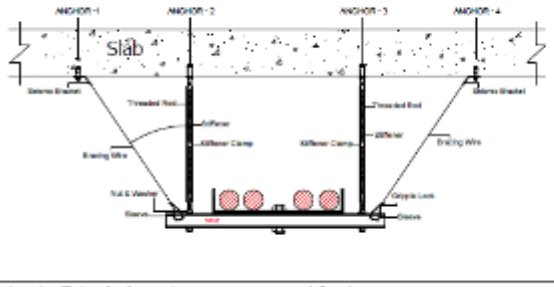
To be mentioned in the submittal documents:

Description	Standard
Seismic Zone	IS16700:2017
Seismic Zone factor	NBC 2016 Table 42 (Clause 5.3.4.2) or as per building seismic zone factor.
Soil Site class	as per site location
Importance Factor (Ip)	IS16700:2017
Component amplication factor (ap)	IS16700:2017
Component response modification factor (Rp)	IS16700:2017
Component response modification factor (Rp) for base isolation	IS16700:2017
Height in structure of point of attachment of component with respect to the base (z)	As per level of attachment of component
Average roof height of structure with respect to the base (h)	As per level of attachment at the roof/slab/peb level
z/h	ratio based on above parameters

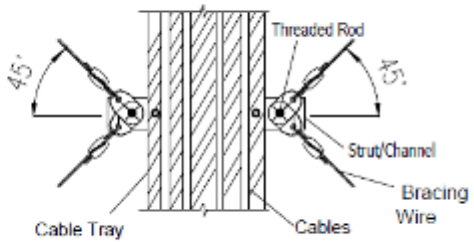
b. For Calculations:

Description	Formula & Values
Seismic Design force In horizontal direction (Fp')	to be part of submittal
Vertical seismic force (Eqy')	to be part of submittal

Typical Arrangement for Cable Tray

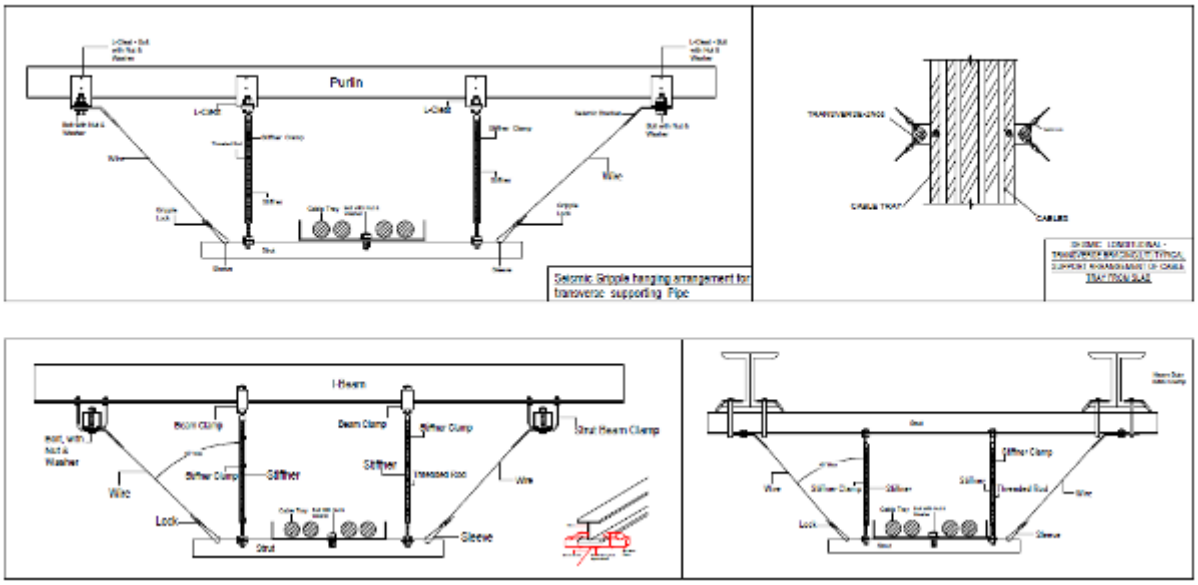


Seismic Gripple hanging arrangement for transverse supporting-Cable Tray



Seismic Gripple hanging arrangement for longitudinal supporting-Cable tray

Typical Hanging Arrangement for Cable Tray



Supporting distance between seismic transverse supports shall not be more than 30 feet and supporting distance between longitudinal supports shall not be more than 60 feet.

NOTE: CABLE TRAY SUPPORTING SYSTEM TO BE DESIGNED BY A COMPETENT AGENCY TO ENSURE SAFETY OF THE INSTALLATION, BUILDING AND THE PERSONS. CONTRACTOR TO HIRE A SPECIALISED AGENCY FOR DESIGN AND INSTALLATION OF THE CABLE TRAY SUPPORT SYSTEM AND ASSUME COMPLETE RESPONSIBILTY ON ADEQUACY OF THE SUPPORT SYSTEM. CONTRACTOR TO SUBMIT A CERTICATE FROM THE STRUCTUAL CONSULTANT ALONG WITH THE DESIGN AND DRAWINGS SUBMITTED TO THE CLIENT/PMC. SIGN AND DRAWINGS SUBMITTED TO THE CLIENT/PMC.

SUBHEAD-R. EARTHING

1. SYSTEM OF EARTHING

The system shall be TNS with 4 wires supply system (R, Y, B, N and 2 Nos. E) brought from the main LT Panel.

All non-current carrying metal parts of the electrical installation shall be earthed as per IS: 3043 – 2018 with latest amendment. All metal conduits, cable sheath, switchgear, DB's, light fixture, equipment and all other parts made of metal shall be bonded together and connected to earth electrodes. Earthing shall be in conformity with provisions of rules 32, 61, 62, 67 and 68 of Indian Electricity Rules, 1956.

All earthing conductors shall be of high conductivity copper or GI, as specified in the schedule of quantities & shall have protection against mechanical damage. The cross-sectional area of earth conductors shall not be smaller than half that of the largest current carrying conductor.

Main earthing conductors shall be taken from the earth connections at the main L T panel to an earth electrode with which the connection is to be made. All joints in tapes shall be with S.S. Straight through or cross connectors or copper brazing in case of copper tapes and by Exothermic welding or bolting or S.S. connectors (straight through or cross connectors) in case of GI tapes. Wires shall be connected with suitable crimping lugs, all bolts shall have plain and spring washers spring washers. Sub- mains earthing conductors shall run from the main distribution panel to the sub distribution panel. Final distribution panel earthing conductors shall run from sub-distribution panel.

Circuit earthing conductor shall run from the exposed metal of equipment and shall be connected to any point on the main earthing conductor, or its distribution panel. Metal conduits, cable sheathing and armouring shall be earthed at the ends adjacent to distribution panel at which they originate, or otherwise at the commencement of the run by an earthing conductor in effective electrical contact with cable sheathing. Where equipment is connected by flexible cord, all exposed metal parts of the equipment shall be earthed by means of an earthing conductor enclosed with the current carrying conductors within the flexible cord. Switches, accessories, lighting fitting etc. which are rigidly secured in effective electrical contact with a run

of metallic conduit shall not be considered as a part of the earthing conductor for earthing purposes, even though the run of metallic conduit is earthed.

a. All Lighting fixtures, sockets outlets, fans, switch boxes and junction boxes etc. shall be earthed with copper wire as specified in schedule of quantities. The earth wire ends shall be connected with solderless/bottle type copper lugs.

b. All the earth wires in switch boxes, sockets outlets, DB's and light fixtures shall be of green Colour (PVC insulated).

c. Main earth bus shall be taken from the L.T. switch board to earth electrodes. The electrical resistance of earthing conductors shall be low enough to permit passage of fault current necessary to operate fuse or circuit breaker, and it shall not exceed 1 ohm.

2. SIZING OF EARTHING CONDUCTORS

The cross sectional area of earthing conductor shall not be smaller than half of the largest current carrying conductor subject to an upper limit of 80 Sq.mm. If the area of the largest current carrying conductor or bus bar exceeds 160 sq.mm then two or more earthing conductors shall be used in parallel, to provide at least half the cross sectional area of the current carrying conductor or bus bars. All fixtures, outlet boxes, junction boxes and power circuits upto 15 amps shall be earthed with FRLS PVC insulated copper wire.

All 3 phase switches and distribution panels upto 60 amps rating shall be earthed with 2 Nos. distinct and independent 4 mm dia copper / GI wires. All 3 phase switches and distribution panels upto 100 amps rating shall be earthed with 2 Nos. distinct and independent 6 mm dia copper / GI wires. All switches, bus bar, ducts and distribution panels of rating 200 amps and above shall be earthed with minimum of 2 nos separate and independent 25 mm x 3 mm copper / GI tape.

Earthing details given in Table – A & B shall be referred to as a general guidance. Exact sizes to be worked out by the contractor as per relevant IS Codes.

TABLE - A

Approximate Sizes of earth leads

(a) For Transformer/Generator Neutral Point Earthing:

Transformer/ DG Set Rating in KVA		Electrolytic Bare copper Conductor Wire or strip		Galvanized Iron Conductor wire or strip
50KVA & below		4mm dia		25mm x 6.0mm
75 KVA		25mm x 3.0mm		25mm x 6.0mm
100 KVA		25mm x 6.0mm		32mm x 6.0mm
150 KVA		25mm x 6.0mm		40mm x 6.0mm
200 KVA		25mm x 6.0mm		40mm x 6.0mm
250 KVA		25mm x 6.0mm		40mm x 6.0mm
300 KVA		25mm x 6.0mm		40mm x 6.0mm
500 KVA		40mm x 6.0mm		50mm x 6.0mm
750 KVA		40mm x 6.0mm		50mm x 6.0mm

1000 KVA		40mm x 6.0mm		50mm x 6.0mm
1250 KVA		50mm x 6.0mm		50mm x 6.0mm
1500 KVA		50mm x 6.0mm		75mm x 6.0mm
2000 KVA		50mm x 6.0mm		75mm x 6.0mm

NOTE: - EXACT SIZE OF EARTH LEAD TO BE DETERMINED BY CONTRACTOR AS PER LATEST IS CODES AND APPROVAL TO BE TAKEN FROM CONSULTANT.

TABLE – B

(b) Approximate sizes of Earth leads for Equipment Earthing (Applicable to Transformer, Generators, Switchgears, Panels, DB's, Motors etc.)

Rating of 400-V, 3ph 50 cy. Equipment In KVA		Bare Electrolytic Copper conductor Wire / Strip	Galvanised Iron Wire / Strip
Upto 5KVA	7A	2mm dia	2mm dia (14 SWG)
6 KVA to 15 KVA	Upto 20A	3mm dia	3mm dia (10 SWG)
16 KVA to 30 KVA	Upto 42A	4mm dia	4mm dia (8 SWG)
31 KVA to 50 KVA	Upto 70A	6mm dia	6mm dia
51 KVA to 100 KVA	Upto 140A	25mm x 3.0mm	25mm x 6.0mm
101 KVA to 125 KVA	Upto 175A	25mm x 3.0mm	32mm x 6.0mm
126 KVA to 150 KVA	Upto 200A	25mm x 3.0mm	32mm x 6.0mm
151 KVA to 200 KVA	Upto 300A	25mm x 6.0mm	40mm x 6.0mm
201 KVA to 300 KVA	Upto 400A	25mm x 6.0mm	50mm x 6.0mm
301 KVA to 500 KVA	Upto 700A	32mm x 6.0mm	50mm x 6.0mm
501 KVA to 800 KVA	Upto 1100A	40mm x 6.0mm	50mm x 6.0mm
Above 800 KVA	Above 1100A	50mm x 6.0mm	50mm x 6.0mm

NOTE: EXACT SIZE OF EARTH LEAD TO BE DETERMINED BY CONTRACTOR AS PER LATEST IS CODES AND APPROVAL TO BE TAKEN FROM CONSULTANT.

NOTE: ALL THREE PHASE EQUIPMENT SHALL BE DOUBLE EARTHED

3. SUGGESTED EARTH SIZES FOR DB'S FOR BODY & 3RD PIN DEDICATED EARTH LINK (FOR UPS DB'S ONLY)
(SUBJECT TO FINAL FAULT CALCULATION AND EARTH SIZE BY CONTRACTOR)

a. 3 Phase LDB's, PDB's, UPS DB's, Pr. AC's (Body Earth):

Cu. Ar. / Al. Ar. Power Cables	Suggested Size of 'GI' Earth Wire
4C x 10 Sq.mm	2 R x 4 mm dia
4C x 16 Sq.mm	2 R x 5 mm dia
4C x 25 Sq.mm	2 R x 5 mm dia
3.5C x 35 Sq.mm	2 R x 5 mm dia

b. 3rd Pin / Dedicated Earthing Link Wiring of UPS DB's / PDU's:
3 Phase Cu. Ar. / Al. AR. Power Cables to UPS DB's / PDU

Cu. Ar. / Al. Ar. Power Cables	Suggested Insulated Earth wire 'Cu' XLPE Insulated for Dedicated Earth Wire
4C x 10 Sq.mm	2C x 6 Sq.mm Cu. Conductor XLPE Insulated Un. Ar. Cable
4C x 16 Sq.mm	2C x 10 Sq.mm Cu. Conductor XLPE Insulated Un. Ar. Cable
4C x 25 Sq.mm	2C x 10 Sq.mm Cu. Conductor XLPE Insulated Un. Ar. Cable

Note: For higher sizes of cables to PDU's take not less than half the size of phase conductor / cable size.

c. Server Room / Hub Room Rack Body & Raised Floor Earthing:

- 1C x 6 Sq.mm FRLS(H) PVC insulated, unsheathed, 600/1100 Volts grade stranded copper conductor single core wire as per IS:694

- 1C x 10 Sq.mm FRLS(H) PVC insulated, unsheathed, 600/1100 Volts grade stranded copper conductor single core wire as per IS:694

d. Modular Workstation Earthing:

- 2.5 Sq.mm FRLS(H) PVC insulated, unsheathed, 600/1100 Volts grade stranded copper conductor single core wire as per IS:694
- 4 Sq.mm FRLS(H) PVC insulated, unsheathed, 600/ 1100 Volts grade stranded copper conductor single core wire as per IS:694

4. PROHIBITED CONNECTIONS

Neutral conductor, sprinkler pipes, or pipes conveying gas, water, or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lighting protection system conductors shall not be used as an earthing conductor.

5. CONNECTION/JOINTS

A. GI Earth Tape Jointing shall be:

a. Bolted Joints for all exposed GI earth tape joints on cable trays:

Tape to tape bolted connections are to be made by sufficiently over lapping two tapes, one above the other and then making connection by not less than two sets of Nuts, bolts & washers. Washers shall be used at both sides. Overlapped joint with 2 sets of bolting arrangement per joint.

Zinc passivated / coated high tensile alloy MS grade 5.6 Hardware shall be used for making joint. (See attached sketches with the specifications).

High grade S.S. hard ware shall be used in coastal areas.

b. Fixing of GI Earth tape on cable tray:

Earth tape bolting on to GI cable trays shall be made by nuts, bolts & washers of same quality as mentioned earlier but at any fixing location on the tray, a small piece of GI tape shall be over lapped on the main earth tape so as to compensate for the area loss due to hole for fixing.

c. Exo Thermic welding of GI earth tape for tape joints buried in ground or clamped on wall, floor, slab:
'UL' listed exothermic welding to be employed for such joints.

d. S.S. Cross / Straight through connectors for GI tape joints clamped on wall, floor, slab:
Cross or straight through connectors may be used for making such joints.

B. Copper Earth Tape Jointing shall be:

a. S.S. Cross or straight through connectors to be used for making such joints.
b. By copper Brazing.
c. S.S. 304 nuts, bolts, plain and spring washers. Overlapped joint with 2 sets of bolting arrangement per joint.

6. EARTHING

The following must always be ensured in earthing system:

- All earth pits should be at equi - potential. Main equipotential bonding conductors shall be provided.
- Extraneous conductive parts such as gas pipes, other service pipes and ducting risers and pipes of fire protection equipment and exposed metallic parts of the building structure shall be bonded to earth.
- The Contractor shall get the soil resistivity test done at his own cost of the area where earthing pits are to be located before starting the installation.

7. RESISTANCE TO EARTH

The resistance of earthing system shall be less than 1 ohm.

SPECIFICATION FOR HOT DIP GALVANIZING PROCESS FOR MILD STEEL USED FOR EARTHING FOR ELECTRICAL INSTALLATION

8. GENERAL REQUIREMENTS

a. **Quality of Zinc**

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS: 209-1992 (refer latest codes).

b. **Coating Requirement**

Minimum weight of zinc coating for mild steel flats shall be in accordance with latest IS:6745-1972 (refer revised code) but shall not be less than 500 gsm & 70 microns coating.
The weight of coating expressed in grams per square meter shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs; rust stains bulky white deposits, blisters.
Recycled steel is not be used for making earth tapes.
Mild steel flats / wires shall undergo a process of degreasing, pickling in acid, cold rinsing and then galvanizing.
Wooden mallet to be used for straightening of GI tapes so that galvinsed coating is not damaged.

9. MAINTENANCE FREE CHEMICAL EARTHING:

Maintenance Free Chemical Earthing shall be done strictly as per manufacturer's recommendations. It shall be completely maintenance free, long life close to 25 years, environmentally safe, non corrosive & electrically conductive. The earth resistance results shall be less than one ohm.

Maintenance Free Earthing System consisting of 1 Nos. CPRI tested 'UL' Listed copper bonded carbon steel core electrode of 25 / 20 mm dia Electrode tested according to IEC 62561-2 and as specified in the BOQ,

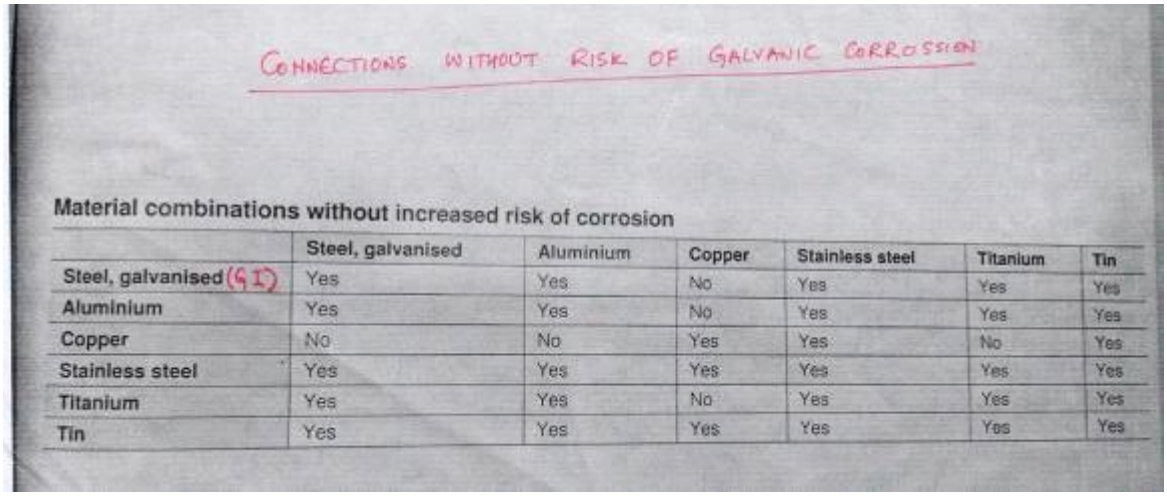
each with a minimum coating thickness of 250 microns and length of 3 meters. 25 kgs/Electrode of earth enhancing compound needs to be considered to fill the 100mm augered hole surrounding to the electrode.

SS Universal Clamp of Size 175X50X3 mm for Connection Terminal to be used..

Earth enhancing compound(OEC) tested as per IEC 62561-7 (miminum 25 kg or more as per requirement) to be used.

Poly Propiline Heavy duty Pit cover to be employed.

10. Galvanic Corrosion between dissimilar materials:



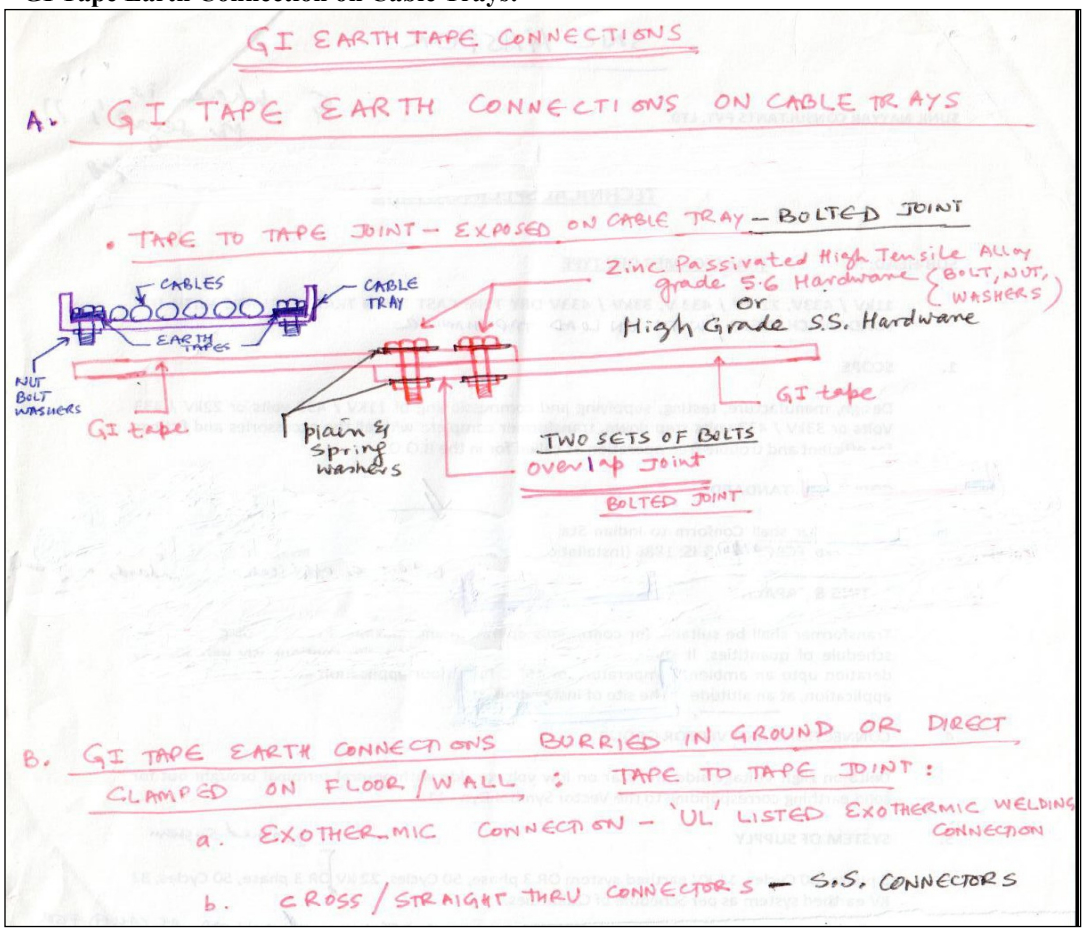
CONNECTIONS WITHOUT RISK OF GALVANIC CORROSION

Material combinations without increased risk of corrosion

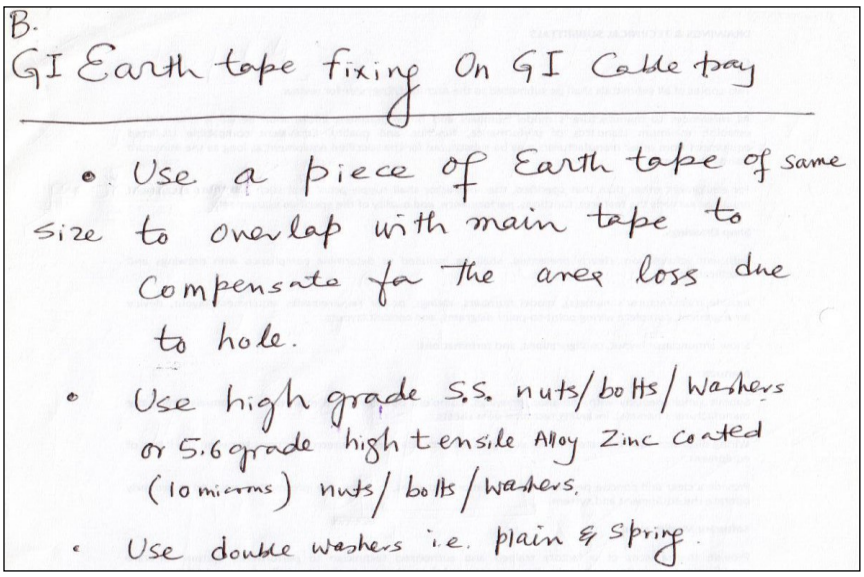
	Steel, galvanised	Aluminium	Copper	Stainless steel	Titanium	Tin
Steel, galvanised (GI)	Yes	Yes	No	Yes	Yes	Yes
Aluminium	Yes	Yes	No	Yes	Yes	Yes
Copper	No	No	Yes	Yes	No	Yes
Stainless steel	Yes	Yes	Yes	Yes	Yes	Yes
Titanium	Yes	Yes	No	Yes	Yes	Yes
Tin	Yes	Yes	Yes	Yes	Yes	Yes

11 GI EARTH TAPE CONNECTIONS

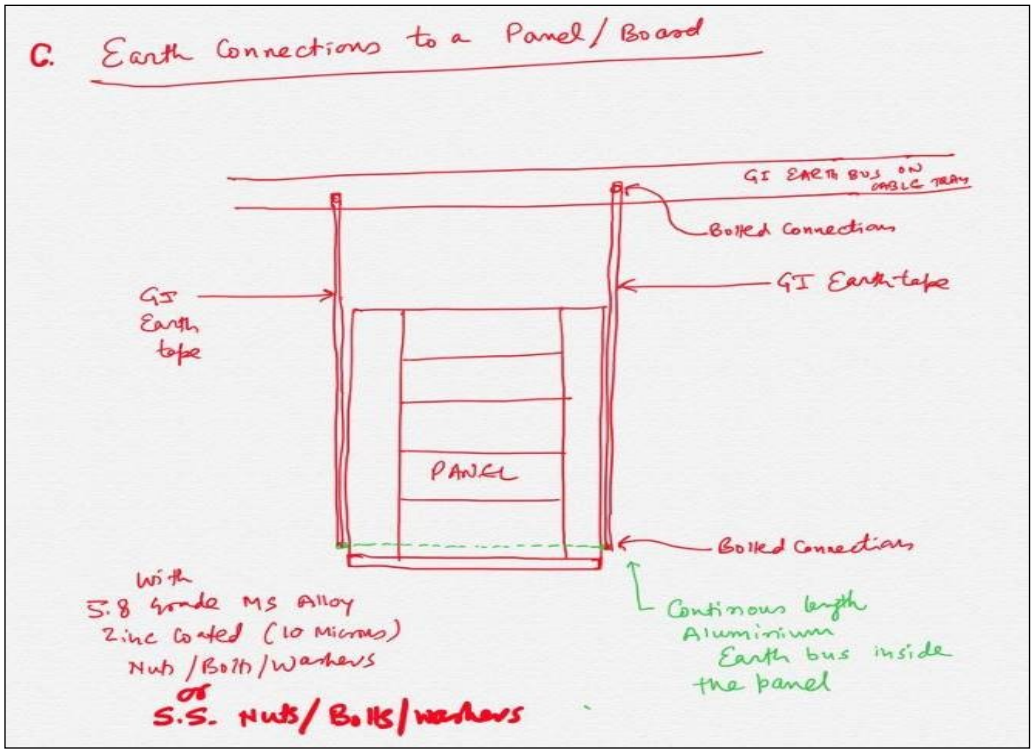
A. GI Tape Earth Connection on Cable Trays:



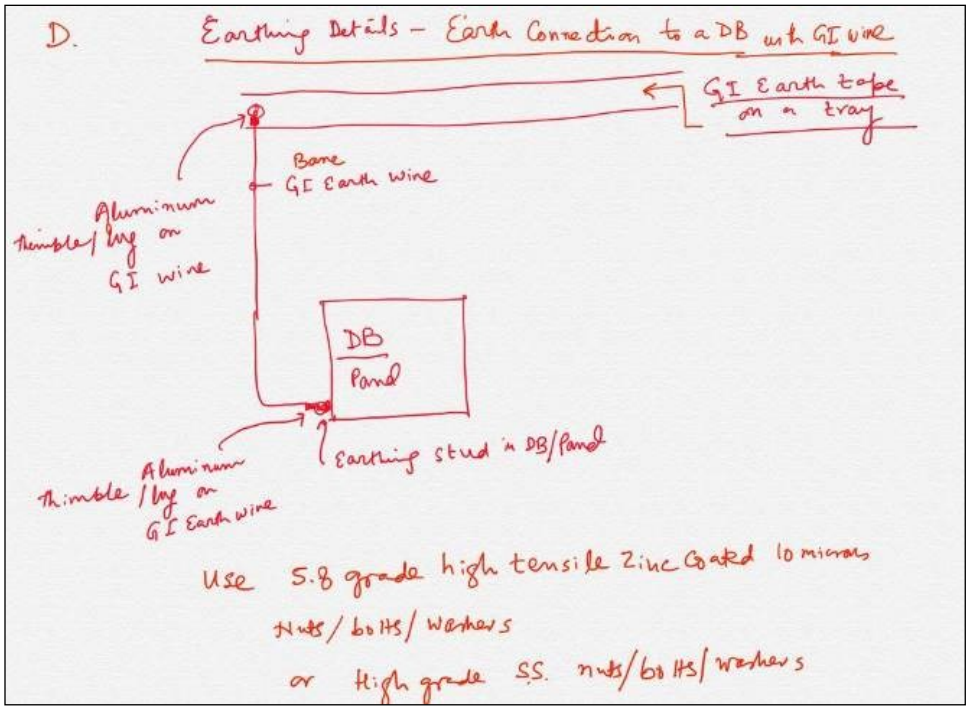
B. GI Earth Tape Fixing on GI Cable Tray:



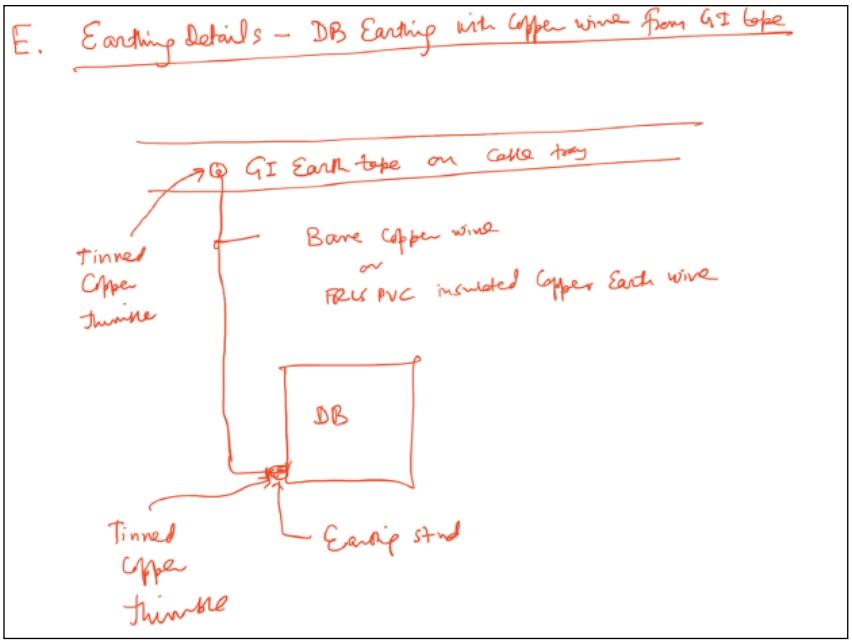
C. Earth Connection to a Panel / Board:



D. Earthing Details – Earth Connection to a DB with GI Wire:



E. Earthing Details – DB Earthing with Copper Wire from GI Tape:



SUBHEAD-S. PANEL & DISTRIBUTION BOARD, LT SWITCH GEAR, VFD'S, STARTERS, IMPORTANT NOTES ON STARTERS, CONSTRUCTION FEATURES AND GENERAL NOTES ON PANELS / DISTRIBUTION BOARDS

1. AIR CIRCUIT BREAKERS (ACB)

- The ACB shall confirm to IEC/IS – 60947-2. The ACB shall have a rated service short circuit breaking capacity (Ics) as specified in SLD's and BOQ "Technical parameters" at rated operational voltage(Ue) at 415V, frequency at 50 Hz. The ultimate breaking capacity (Icu) shall be equal to Service breaking capacity (Ics) and Short Ckt Withstand capacity (Ics=Icu=Icw for 1 see) rated Impulse withstand voltage(Uimp) shall be 12kv and rated insulation voltage (Ui) at 1000V. The ACB release should have true RMS sensing. ACB should have single frame size up to 4000A and shall be suitable for "Switch Disconnect" function (AC 23 utilization category). The construction of circuit breakers shall be as per **pollution degree 3**.
- Circuit breakers shall be three / four pole, air break, horizontal drawout / fixed type as indicated in SLD/BOQ.
- Drawout type Circuit breakers alongwith its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.
- There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "TEST" position the circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLY WITHDRAWN" position. Safety interlock must be provided to prevent the ACB from falling out in a fully withdrawn position. It shall be possible to close the door in "TEST" position.
- Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE", "TEST", and "SPRING CHARGED" positions.
- All ACBs should be provided with Microprocessor based release as specified in BOQ / SLD's should be provided on circuit breaker for short circuit, over current and earth fault protection with adjustable settings with intentional delay. Specific LED indications should be provided for short circuit, over current and earth fault operation for faster fault diagnosis and reduced down time. All ACBs should be provided with "Auto Protection" facility. Opening and closing time of ACB should be <40 m Sec and <70 m sec respectively. All Incomer ACB Release should be provided with display for current and voltage parameters (for each phase & Ground Fault). Control unit shall have fault history data & store **last 10 trip causes**.
  The Circuit Breaker shall have minimum **mechanical life of 10000** operations **without maintenance**.

  The electrical life of circuit breaker upto 2000 Amps shall not be less than 5000 operations and beyond 2000 Amps shall be greater than 1000 operations.
  ACB releases shall be EMI / EMC compatible. In case of Four Pale ACB , Fully rated Neutral with protection against O/L & S/C with settings at 50%-100%- OFF. ACBs should comply with RoHS. Microprocessor releases shall be provided with integral LCD Display of load current and individual loading of all the three phases. Microprocessor release shall also be suitable for zone selective interlocking (ZSI) . Microprocessor releases shall also have I^2t ON/OFF time delay protection for short circuit and Earth fault.
  All ACBs release shall have in-built thermal memory before and after the fault. ACB release should be provided with Rotary Dial for release setting. Separate LEDs should be provided on release itself for fault differentiation.
- Relays should be CT operated through shunt trip, under voltage trip for short circuit and earth fault protection.

- Wherever microprocessor earth fault release is asked for. Additional CT shall be provided on the neutral bus link. This CT shall have characteristics matching to the CT's installed in the ACB for the purpose. It should be possible to change the setting of release in "ON" condition.

- All circuit breakers shall be provided with "4 NO" and " 4NC" potential free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker and should be directly operated from breaker operating mechanism.
- All circuit breakers shall be provided with the following interlocks :

- Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed circuit breaker shall preferably not trip the circuit breaker. In cases the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exist between the fixed and drawout contact at the time of breaker trip, so that no arcing takes place even with the breaker carrying it's full rated current.

- Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.
  All ACB's shall have **door interlock**
- Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.
  ACBs shall be provided with a flexibility to rotate power terminals by 90 degree to suite stringent site requirements.
- A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

- There should be a provision of positive earth connection between fixed and moving portion of the ACB either through connector plug or sliding solid earth mechanism. Earthing bolts must be provided on the cradle or body of fixed ACB.

- It should be possible to bolt the drawout frame not only in CONNECTED position but also in TEST and DISCONNECTED position to prevent dislocation due to vibration and shocks.
- Circuit barkers shall provide with castle key / electrical interlocking devices, as specified in "Bill Of Quantity".
- Mechanical tripping shall be possible by means of front mounted Red "trip" push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.
  The **racking handle shall be stored on the air circuit breaker** in such a manner as to be accessible without defeating the door interlocking
- Alternatively Means shall be provided to slowly close the circuit breaker in "withdrawn position", if required, for inspection and setting of contacts. In "service position" slow closing shall not be possible.

- All accessories like shunt release, undervoltage, motorized mechanism etc. shall be front mounted, requiring no adjustments and can be fitted at site.

- The manufacturer shall provide details of opening time and duration with temperature to ensure discrimination and proper selection for feeder protections. All ACB's of 4000A and above shall be a single ACB unit. The manufacturer shall also indicate the mechanical and electrical life of circuit breaker.

- Circuit breaker shall be provided with either of the following mechanisms as specified in "Bill Of Quantity".
  The trip unit shall have following protection settings, based on the type of trip unit.
  - Adjustable over load current (Ir) settings from 40% to 100% of rating of ACB (In).
  - Over load time setting (tr) from 0.5s, 1s, 2s, 4s…….24s as field selectable curves
  - Short circuit setting (Isd) from 1.5 to 10 times of Ir setting
  - Short circuit time delay adjustable from 0 to 400 msec.
  - Instantaneous (Ii) protection with an adjustable pick-up and an OFF position.
  - Earth fault setting adjustable in absolute Ampere with time delay settings from 0 to 400 ms.

1.01 Manually Operated Mechanism

- Manually operated mechanism shall be of manual spring charging stored energy type.
- The circuit breaker shall have a spring charging handle and push-button for closing the breaker mechanically after the spring has been charged. However, closing by spring charging handle after the spring has been

fully charged shall also be acceptable, provided the movement of contacts does not take place with the movement of handle and the contacts operate only when the spring stored energy is released. Overcharging of spring shall not be possible.

- The closing action of the circuit breaker shall charge the tripping spring, thus making it ready for tripping.
- The circuit breaker shall be provided with the interlocks so that it shall not close unless the spring is fully charged.
- The mechanism shall be suitable for addition of motor mechanism at site if required for future upgrade without the need of any special accessories.

1.02 Power Operated Mechanism

- Power operated mechanism shall be provided with a universal motor suitable for operation on 240 AC / DC Control supply, with voltage variation from 90% to 110% rated voltage. Motor insulation shall be class "E" or better.
  All ACBs should be provided with "Ready to Close" Contact
- The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring at minimum available control voltage.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
- The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operation shall be possible. After failure of power supply at least one open-close-open operation shall be possible.
- Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.
- All circuit breakers shall be provided with closing and trip coils (Shunt release + Under voltage release). The closing coil shall operate correctly at all values of voltage between 85% to 110% of rated control voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% of rated control voltage and shall have continuous rating.
- Provision for mechanical closing of the breaker only in "TEST" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.

2.00 **MOULDED CASE CIRCUIT BREAKERS (MCCB'S)**

- The Moulded case circuit Breaker (MCCB) shall confirm to the latest IEC 60947-2 and IEC 947-3-1989. MCCB's shall be suitable for rated operation voltage upto 415 VAC & rated insulation voltage upto 690 VAC.
- MCCB's in AC circuits shall be of triple pole / four pole construction as per enclosed BOQ. Operating mechanism shall be quick-make, quick-break and trip-free type (Roto-Active design) . The "ON", "OFF" and "TRIP" positions of the MCCB's shall be clearly indicated and visible to the operator when mounted as in service. Front of door operating handle shall be provided with pad lock and door interlock. Front of door operating handle shall be provided with door interlock defeat mechanism to facilitate inspection of the MCCB during 'ON' position. MCCB shall be suitable for Positive isolation / disconnection according to IEC 60947-1 & 2 for optimum user safety.
- The Service short circuit Breaking capacity (Ics at 415 VAC) of all MCCB's shall be as specified in SLD / BOQ and shall have (Ics=Icu=100%).
  All MCCB should have "Class-II" front facia as per IEC 60664.
  Electrical life of MCCB's shall not be less than 10000 operations and mechanical life shall not be less than 20000 operations.
- The MCCB shall be current limiting type. MCCB shall have Arc extinguishing device contained in a compact, high strength, heat resistance, flame retardant, halogen free insulating moulded case with high withstand capability against thermal and mechanical stresses.
- MCCB's shall be either with Thermal-magnetic releases for over load and short circuit or with microprocessor based releases for over load and short circuit as mentioned in the Electrical Single Line Diagram (SLD) / SLD Notes and / or in the BOQ.
  Load indication LED shall be integral part of electronic releases. All electronic releases shall be EMI / EMC compatible.

- Wherever microprocessor earth fault add on earth fault Module is asked for, additional CBCT shall be provided.
  It should not be possible to by pass / switch off the S/C, E/F protection in MCCB. The E/F setting should be provided with 10% to 60% with time delay of 0.3 to 3 seconds. LED Indication should be provided in case of earth Fault. E/F Module should have Test Push Button for self diagnostic features without tripping the ckt breaker. Also Over current and earth fault differentiation should be provided.
- The trip command of releases in MCCB shall over ride all the other commands. The MCCB shall employ maintenance free double break contact system to minimize the set through energies and capable of achieving Total Discrimination up to the full short circuit capacity of the downstream MCCB. The MCCB shall not be restricted to line / load connections. MCCB shall be provided with test trip Push Button to check the proper function of tripping mechanism. MCCB shall comply with RoHS & WEEE norms
- Where Earth fault protection are indicated in drawings / BOQ they shall be thru Add on Module MCCB's and have adjustability from 10% to 60% of rated current with adjustable time delays to aid discrimination on earth faults. The system shall be immunized against nuisance tripping as per IEC 61000-4 standards.
- MCCB's shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 8 milliseconds.
- MCCB terminals shall be shrouded and designed to receive Bus Bar Links /cable lugs for cable sizes relevant to circuit ratings.
- The MCCB shall have common field fittable snap-on auxiliaries common for entire range. The remote tripping coil should be of continuous duty cycle.
- Where mechanical interlocking is called-for between two Incomer and Bus Coupler or between two Incomers without Bus Couplers, proper arrangement for built-in Ronis / Coded key interlocking shall be provided.
- MCCB's shall be with bus bar spreaders. (Spreaders shall be of the same make of MCCB i.e. spreaders shall come along with the MCCB, to be supplied by the MCCB manufacturer).
  MCCB's shall be with direct / extended Rotary Handle.

  ARRANGEMENT OF PAD LOCKING & FOOL PROOF LOTO (LOCKOUT & TAG OUT) TO BE AVAILABLE WITH ALL MCCB'S FOR MAINTENANCE SAFETY REASONS ON MOTORS / EQUIPMENT.

3.00 ATS SPECIFICATIONS

Type-1 Equivalent to 'ASCO' make Series 7000 for above 1200Amps and Series 300 below 1200 Amps ATS as per UL 1008A	• ATS (ATS & Controller) 100% overlapping neutral as per IEEE 446 for unbalanced system • In phase monitoring is possible i.e. same phase angle transition. • Phase Angle monitoring • DG Supply to Main Supply transition time: 50 ms • RS485 communication • Solenoid operated • Upto 5000A rating Fault withstand: • 85 KA for 0.3 Sec • 50KA to 0.5 Sec • Utilization category – AC 33A • Controller with AMF function	Usage: • Main LT Panel • Fire Emergency Panel • DG Set Aux. Panel

Type-2 Equivalent to 'ASCO' make Series 300 ATS as per UL 1008A	(ATS & Controller) (Switch is same as 7000 series but control is different) • 100% overlapping neutral as per IEEE 446 for unbalanced system • In phase monitoring Not possible. • Transition on same phase angle not possible. • Solenoid operated • No communication Fault withstand: • 85 KA for 0.3 Sec • 50 KA to 0.5 Sec • Utilization category – AC 33A • Controller with AMF function	Usage: • UPS Input Panel • Lift Panel
Type-3 Equivalent to 'ASCO' make Series 230 As per IEC 60947-6-1	• ATS with motorized operation with inbuilt controller • No overlapping neutral • No communication • Utilization category – AC 33B	

4. MOTOR PROTECTION CIRCUIT BREAKER (MPCB)

Motor circuit breakers shall 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 shall 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 shall have a rated impulse withstand voltage (Uimp) of 6 kV. The motor circuit breakers shall be designed to be mounted vertically or horizontally without derating. Power supply shall 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 shall close, open, and trip simultaneously. The motor circuit breakers shall 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 shall be possible. The front-mounting attachments shall 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 shall have a combination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination shall enable type 1 or type 2 co-ordination of the protective devices conforming to IEC 60947-4-1.Type 2 co-ordination shall 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 shall 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) shall 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 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).

MPCB shall be with bus bar spreaders. (Spreaders shall be of the same make of MPCB i.e. spreaders shall come along with the MPCB, to be supplied by the MPCB manufacturer). MPCB'S shall be with direct / extended rotary handles.

ARRANGEMENT OF PAD LOCKING & FOOL PROOF LOTO (LOCKOUT & TAG OUT) TO BE AVAILABLE WITH ALL MPCB'S FOR MAINTENANCE SAFETY REASONS ON MOTORS / EQUIPMENT.

MPCB's shall be with microprocessor-based releases. MPCB's shall be two of types as called for in the bill of quantities as follows:

a) MPCB's shall be with thermal & magnetic releases with adjustable thermal setting.
b) MPCB's with magnetic release only shall be with fixed magnetic setting.

5. MINIATURE CIRCUIT BREAKER (MCB)

- Miniature Circuit Breaker shall comply with IS 8828 – 1996 / IEC 898 – 1995.
- Miniature Circuit Breaker shall be quick make and break type for 230 / 415 V AC and 50 Hz application. The housing of MCB's shall be heat resistant and having a high impact strength. The breaking current of MCB's shall not be less than 10000 Amps, at 230 V / 415 V. The MCB's shall be flush mounted and shall be provided with trip free manual operating mechanism with mechanical 'ON' and 'OFF' indications. MCB's shall be suitable for isolation function and line load reversibility.
- MCB's shall be current limiting type class – 3. MCB's shall be classified as B, C, and D as per standard Ref. IS as per the Tripping characteristics curves defined by all the manufactures. The MCB shall have the minimum power loss (Watts) per pole defined as per the IS / IEC and the manufactures shall publish the value.
- MCB's shall be calibrated at an ambient temperature of 40 degree.
- The MCB contacts shall be silver nickel alloy and contact tip coated with silver. Proper arc chutes shall be provided to quench the arc immediately. MCB's shall be provided with magnetic coil releases for short circuit protection and thermal release for over load protection. The over load or short circuit devices shall have a common trip bar in the case of DP, TP, TPN and FP Miniature Circuit Breakers and shall have 20000 electrical operations upto 63A. The terminals shall be protected against finger contact to IP 20 Degree of protection.
- MCB's shall have a facility to accommodate accessories like auxiliary contacts, trip alarm contact, shunt trip and under voltage add-on blocks.

Use of MCB's shall be application based i.e.: (Even if it not mentioned specifically in the BOQ)

For computers / IT equipment / Servers	:	Type 'D' characteristics
For motors, inductive loads and Discharge Lamps	:	Type 'C' characteristics
For lighting & small power	:	Type 'B' characteristics

MCB's 'KA' RATINGS:

- MCB's are available in standard 10 KA fault with stand rating indigenously produced.
- Imported MCB's in 16KA, 25KA & 36 KA fault ratings are also available.
- 16KA fault rating may be 15% more expansive than 10 KA rating.
- For 25KA & 36KA MCB rating wherever required, MCCB / MPCB may be opted for cost & delivery reasons.

6. RESIDUAL CURRENT CIRCUIT BREAKER CURRENT OPERATED TYPE (RCCB)

- The RCCB / ELCB should comply with IEC 1008 and shall be suitable for use with pure AC/AC with DC off set, for frequency range of 50 Hz to 400 Hz. The RCCB / ELCB shall be protected against nuisance tripping by a protective device, limiting such tripping to a peak value of 250 A according to the 8/20 wave for instantaneous devices. RCCB's / ELCB's shall be suitable for isolation function and line load reversibility.
- EL + MCB / RCCB shall have Earth leakage, over load and short circuit protection where as ELCB shall have Earth leakage protection only. RCBO / RCCB wherever provided in Computer systems / IT equipment's shall

be super immunized / equivalent, even if it is not specifically mentioned in the BOQ, it needs to be provided for such circuits.

- EL + MCB / RCCB / ELCB shall be quick make and break type. The housing shall be heat insulated and having a high impact strength. The moving contacts of the Phases shall be mounted on a common bridge, actuated by a rugged toggle mechanism for closing / opening of all the three phases simultaneously. The neutral moving contact shall be so mounted on the common bridge that at the time of closing, the neutral makes contact first before the phases and at the time of opening, the neutral breaks last after allowing the phases to open first.
  The core balance transformer ensures positive detection of earth leakage currents. The incoming current shall pass through the torroidal core transformer. As long as the current in the phase and the neutral shall be the same, no electromotive force shall be generated in the secondary winding of the transformer. In the event of a leakage to earth, an unbalance shall be created which will cause a current to be generated in the secondary winding, this current shall be fed to a highly sensitive relay, which shall trip the circuit if the earth leakage current exceeds a predetermined critical value. The device shall be current operated independent of the line voltage, current sensitivity of 30mA/100mA/300mA at 240 / 415V AC as called for in the BOQ.
- EL + MCB / RCCB / ELCB shall have trip free nature of mechanism ensuring that it cannot be closed when an earth leakage fault persists.
- Test device shall be there to check the integrity of earth leakage detection system and the tripping mechanism. It shall have box type terminals and capture screws ensuring easy connection of cables and protected against finger contact to IP 20 Degree of Protection.

7. METERS

a. All voltmeters / multi-function meters and indicating lamps shall be protected through MCB's / MPCB's depending upon fault level.
b. Meters and indicating instruments shall be flush type.
c. All CT's connection for meters shall be through Test Terminal Block (TTB).
d. CT ratio and burdens shall be as specified on the Single line diagram/ in the BOQ/ as required for the application.

8. CURRENT TRANSFORMERS (CT'S) & VOLTAGE / POTENTIAL TRANSFORMERS (PT'S)

Current transformers shall be provided for Distribution panels carrying current in excess of 60 amps. All phase shall be provided with current transformers of suitable VA burden with 5 amps secondary's for operation of associated metering.
The CTs shall confirm 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. Secondary terminals of CTs shall be brought out suitable to a terminal block which shall be easily accessible for testing and terminal connections. The protection CTs shall be of accuracy class 5P10 and metering CTs shall be of accuracy class I.
Accuracy class and VA burden shall be as per the application as required as per metering / protection needs.
PT shall be Class-1 accuracy for metering.
PT shall be cast resin type.
PT shall be of suitable burden (VA).

9. INDICATING PANEL

All meters and indicating instruments shall be in accordance with relevant Indian Standards. Meters shall be flush mounted digital type. Indicating lamps shall be of low burden, and shall be backed up with 2 amps MCB/MPCB as per required fault level. Indicating Lamps shall be of LED type. All digital instruments shall have shrouded terminals and suitable for 0°C to 50°C temperature range and shall with stand 1.2 time over loading. Accuracy class and VA burdens shall be as per the requirement. Meters shall be with RS 485 port wherever called for in the BOQ's for communication.

10. SELECTOR SWITCH

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

11. CONTACTOR

Contactor shall be built into a high strength thermoplastic body and shall be provided with a shield for quick are extinguishing. Silver alloy tips shall be provided to ensure a high degree of reliability and endurance

under continuous operation. The magnet system shall consist of laminated yoke and armature to ensure clean operation without hum or chatter.

Starter's contactors shall 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 Starters. The insulation for contactor coils shall be of Class "E".

Coil shall be tape wound vacuum impregnated and shall be housed in a thermostatic bobbin, suitable for tropical conditions and shall withstand voltage fluctuations. Coil shall be suitable for 240 / 415 + 10% volts, 50 cycles AC supply. Contactors shall be of 3P / 4P design as required.

12. THERMAL OVERLOAD RELAY

Thermal overload relay shall have built in phase failure sensitive tripping mechanism to prevent against single phasing. The relay shall 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 –5deg C + 55 deg C.

All overload relays shall be of three element, positive acting ambient temperature compensated time logged thermal over load relays with adjustable setting. Relays shall be directly connected for motors upto 35 HP capacity. C.T. operated relays shall be provided for motors above 35 HP capacities.

13. TIME DELAY RELAYS

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

14. TOGGLE SWITCH

Toggle switches, where called for in Schedule of Quantities, shall be in conformity with relevant IS codes and shall be of 5 amps rating.

15. PUSH BUTTON STATIONS

Push button 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 shall be provided for 'Stop' push buttons. The push button contacts shall be suitable for 6 amps current capacity.

16. Coordination Study In LV Network

LV Switchgear Manufacturer shall submit coordinated & Discriminated solution for LV Network protection devices i.e. **ACB, MCCB, MPCB &** MCB for all Incoming and outgoing devices for all Panels/ DB`s as per BOQ with the help of published discrimination tables. Total discrimination shall be provided up to the short circuit breaking capacity of downstream circuit Breakers.

17. CAPACITORS:

17.1 Power Factor Improvement Capacitors:

- The power factor improvement capacitors shall be heavy duty Dry type MPP (metalized poly propelene type).
- The MPP type capacitors shall be made with impregnation technology. The capacitor shall be made using three capacitor elements wound wired internally in a delta connection with PPMh and positioned inside a metal case. Impregnation shall be Dry resin filled.
- The capacitors shall be meant for continuous duty.
- Capacitors shall be rated for 525V for harmonics environment with 14% De -tuned reactors per bank where non liner IT loads, VFD's UPS & other similar loads are present like in IT buildings, Office buildings, Data Centres, Hotels, Malls/Retail ,Hospitals, Airports, factories, Industrial Installation, Corporate offices, Universities and Schools/Colleges and High and Medium End Housings/Apartment Buildings . Normal housings/Apartments shall have 480V rated capacitors with 7% De-tuned reactors per bank.
- The operating voltage of normal application shall be 415V / 440V.
- Dielectric losses shall less than or equal to 0.2W /Watt / KVAR.
- Capacitance tolerance shall be within the range of – 5 to + 10%.
- The rated frequency shall be 50 Hz ±3%.
- Life expantancy shall be equal to or more than 170000 hours.

- The reference standard for capacitors shall be IEC 831-1/2.
- Capacitors should have high over load capabilities with good thermal & mechanical protections.

- Capacitors should be selected / sized in such a way that actual required capacitance is available at 415V. That means more capacitance need to be provided while using 525V /480 V rated capacitors as the case may be to meet the required capacitance in terms of KVAR.

17.2 Harmonic circuit filter reactors 7% & 14%:

- Harmonic circuit filters shall be strip / wire wound, copper type construction.
- These shall be designed for low loss. The losses shall be less than 5W / KVAR.
- It shall be vacuum impregnated.
- The class of insulation shall be H class, 180 deg C.
- The reactors are made out of an iron core and air gap.
- It shall have low temperature rise & lower flux density so that it operate in worst conditions of ambient & harmonic loads.
- These should offer good degree of linearity and low losses.
- The filter reactors shall have filtering factor of 7% and 14% as called for in the BOQ.
- These filters are designed for protection of capacitors against Harmonics.

Note: Make: Schneider Electric, Siemens, ABB

17.3 Automatic power factor correction relay:

- The relay shall be an intelligent relay which should measure, monitor and control reactive energy. Relay shall be 3 Phase type.
- It shall automatically monitor the power factor, monitor all the connected capacitor steps with real time power in KVAR.
- The relay shall be communicable with RS 485 modbus protocol.

17.4 Capacitor Duty Contactors:

- Contactors shall be suitable for 415V / 440V supply & shall be suitable for capacitor duty.

18. VARIABLE FREQUENCY DRIVE (VFD'S)

18.1 SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, delivery at site, installation, testing, commissioning and carrying out performance test at site of Variable Frequency Drives.

18.2 CODES and STANDARDS

The design, materials, construction features, manufacturer, inspection, testing and performance of variable frequency drives shall comply with all currently applicable statues, regulations, codes and standards in the locality where the system is to be installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility. In particular, the air distribution system shall conform to the latest edition of following standards.

18.3 GENERAL REQUIREMENTS

- ✓ 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.
- ✓ The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered design.
- ✓ The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.

- ✓ The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. VFD shall be manufactured in ISO 9000, 2000 certified facilities.
- ✓ The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
- ✓ The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.
- ✓ The manufacturer shall have been engaged in the production of this type of equipment for a minimum of thirty years.

✓ The frequency converter shall be supported locally by the manufacturer who will provide full technical support, spares holding and troubleshooting capability from their own local facility. A training course shall be provided by the manufacturer to the consultant / contractor / maintenance engineers.

- ✓ To ensure adequate technical and factory support, VFDs manufactured by others and brand labeled shall not be acceptable.

18.4 TECHNICAL REQUIREMENTS

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

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

The VFD shall have a dual 5% impedance DC link reactor (harmonic filters) on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable.
VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

IEEE519, 1992 recommendations shall be used for the basis of calculation of total harmonic distortion (THD) at the point of common coupling (PCC). On request VFD manufacturer shall provide THD figures for the total connected load. The contractor shall provide details of supply transformer rating, impedance, short circuit current, short circuit impedance etc to allow this calculation to be made.

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

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

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

A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.

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

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

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

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

VFD shall minimize the audible motor noise through the used of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.
The VFD shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.

18.5 PROTECTIVE FEATURES

A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.
Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.
Protect VFD from input phase loss : The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
Protect from under voltage : The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.
VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.
If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.
The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.
Protection from output switching: The VFD shall be fully protected from switching a contactor / isolator at the output without causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode.
The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.
When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

18.6 INTERFACE FEATURES

Hand, Off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.
There shall be an "Info" key on the keypad. The Info key shall include "on-line" context sensitive assistance for programming and troubleshooting.
The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.
Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.
All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
Keypad shall provide visual indication of copy status.
Display shall be programmable to communicate in multiple languages including English, Chinese, Korean, Japanese, Thai and Indonesian.
A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.
A three-feedback PID controller to control the speed of the VFD shall be standard.
This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.
The VFD shall be able to apply individual scaling to each feedback signal.

For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.
The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.
The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide setpoint reset.
Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others.
Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a "wake-up" feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.
A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.
VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in ^{0}C , return air temperature in ^{0}C , supply air temperature in ^{0}C, CO_2 concentration in ppm, pressure in bar, differential pressure in PSI etc.
VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.
Standard Control and Monitoring Inputs and Outputs
Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.
Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.
Each relay shall have an adjustable on delay / off delay time.
Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.
Each shall be independently selectable to be used with either an analog voltage or current signal.
The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.
A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting, One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.
It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications.
It shall be possible to command all digital and analog output through the serial communication bus.
Optional Control and Monitoring Inputs and Outputs It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.
These modules shall use rigid connectors to plug into the VFD's control card.
The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.
Modules may include adequate number of such items as may be required as follow:
Additional digital outputs
Additional digital inputs
Additional analog outputs
Additional analog inputs, including Ni or Pt temperature sensor inputs
Additional relay outputs (minimum 2 NO + 2 NC) suitable for 230 V, AC.
It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

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

A real-time clock shall be an integral part of the VFD.

It shall be possible to use this to display the current date and time on the VFD's display.

Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

All VFD faults shall be time stamped to aid troubleshooting.

It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.

The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

Comparators for comparing VFD analog values to programmed trigger values

Logic operators to combine up to three logic expressions using Boolean algebra

Delay timers

A 20-step programmable structure

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

18.7 SERIAL COMMUNICATIONS

The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
Metasys N2
Modbus RTU
VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.
The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

18.8 ADJUSTMENTS

The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.
Four independent setups shall be provided.
Four preset speeds per setup shall be provided for a total of 16.
Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds.
Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.
If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.
The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

An automatic "start delay" may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.
Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

18.9 OPTIONAL FEATURES

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

18.10 SERVICE CONDITIONS

mbient temperature at full speed, full load operation with continuous drive rated output current:

-10°C to 45°C for ratings upto 90 kW without derating

-10°C to 40°C for ratings 110 kW and higher without derating

Relative Humidity : 0 to 95%, non-condensing.

Elevation : Up to 3,300 feet without derating.

AC line voltage variation : + 10% of nominal with full output.

VFD Enclosure protection : IP 20 with Mains Disconnect switch, integral, with no additional cabinets. – Not applicable. Protection shall be for Indoor installation.

Side Clearances : No side clearance shall be required for cooling.

All power and control wiring shall be done from the bottom.

All VFDs shall be plenum rated.

All the contacts mounted on each VFD should be brought to the terminal blocks of each starter in order to enable BMS vendor to do termination of his cables. None of the terminations of the BMS cables be done directly to the VFD.

18.11 QUALITY ASSURANCE

To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

All optional features shall be functionally tested at the factory for proper operation.

18.12 SUBMITTALS

This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

18.13 ADDITIONAL NOTES

- VFD's should have inbuilt DC choke.
- THDI on current side shall be limited to 35% to 40% (Total harmonics distortion).
- VFD's shall be complete with RFI & EMC filters as may be required for type of building/installation/project to limit the interference .

- VFD's to work with input voltage variation of 415V ± 10%
- IP 20 for installation inside panels.
- In open : IP 55

18.14 IMPORTANT NOTES:

A. HARMONIC FILTERATION

i. VFD'S FOR CHILLER

- Chiller VFD shall have passive harmonic filters comprising LC circuit with inductance and capacitance to achieve THDI not more than 25%.
- Passive filtration shall be part of / inclusive in VFD enclosure / VFD Panel.

ii. VFD FOR AHU'S, FAN'S AND PUMPS:

- VFD's for AHU's, Ventilation and Pressurization fans & pumps shall have DC Chokes to achieve THDI not more than 40%.
- DC chokes shall be part of / inclusive in VFD enclosure.

B. EMC & RFI FILTRATION

VFD's for sensitive installations where life critical data communications are of importance ,like:

- Hospitals
- Airports
- Electronic Industry
- Data centres
- Communication centres

These installations Must have 'C1' category of RFI & EMC filters for 50 meters of cable length. These are applicable to all the VFD's of AHU's, fans, blowers, pumps, cooling towers & chillers. . For these above mentioned critical applications, if chiller motors and pump motors are more than 90Kw, then 'C2' category of filters to be used if 'C1' is not available.

VFD's for normal buildings and others similar installations shall have 'C3' category of RFI & EMC filter for AHU's, fans, blowers, pumps, cooling towers & Chillers.

C. METERING DISPLAY OF VFD'S

The following parameters shall be available on display in the VFD:
A, V, Hz, PF, KW, KWH, KVA, KVARH, KVAH

D. PROTECTION OFFERED BY VFD

It must offer, overload, short circuit, over & under voltage, single phasing and earth fault protections to motors.

E. VFD STATUS:

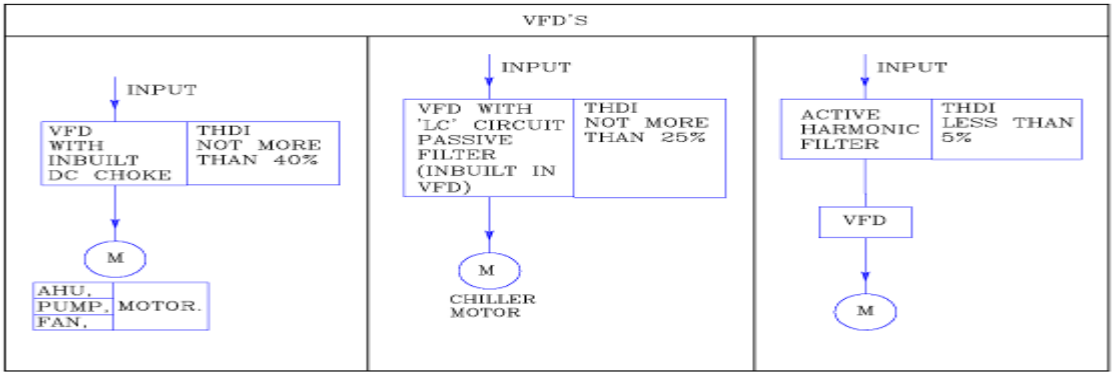
VFD display screen will display faults like:

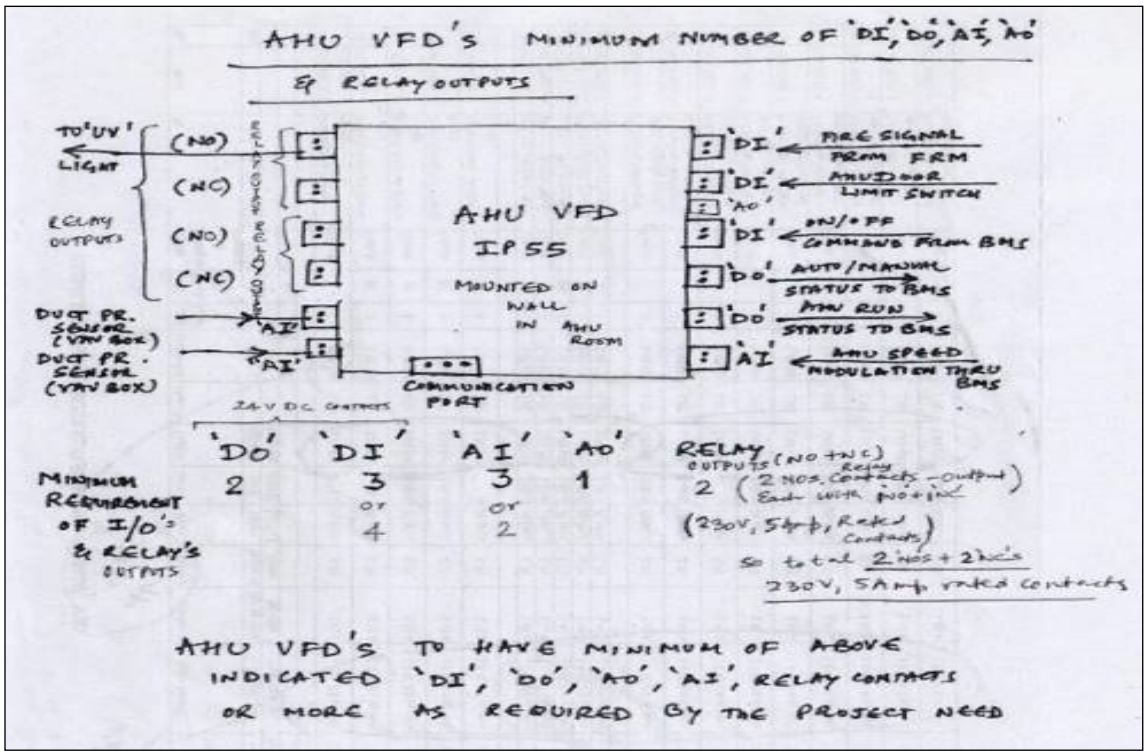
- Over current i.e. over load.
- Phase loss i.e. single phasing & will trip.
- A small light will start blinking on the screen also and this will go off only when a fault is removed and drive is 'RESET'.
- These status details will also be available at BMS.

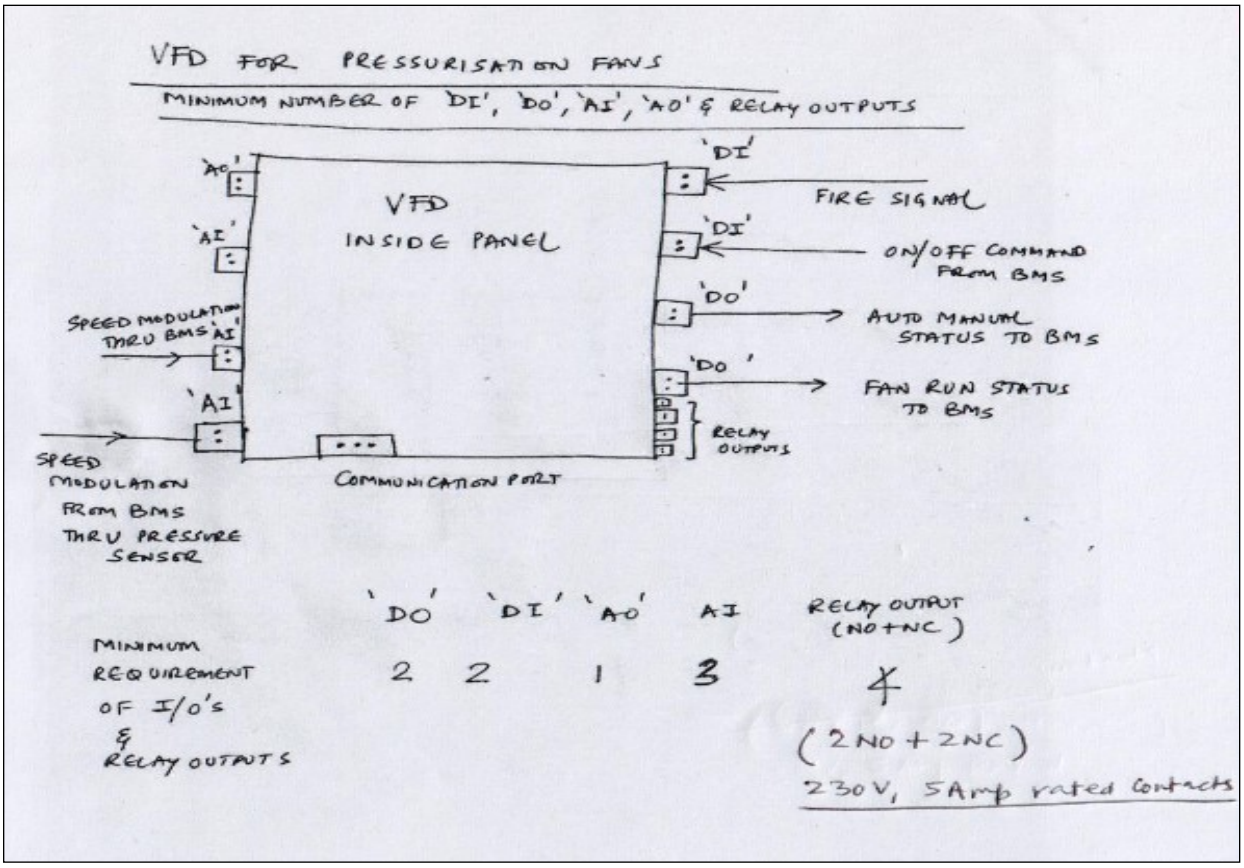
VFD Front Display & Buttons:

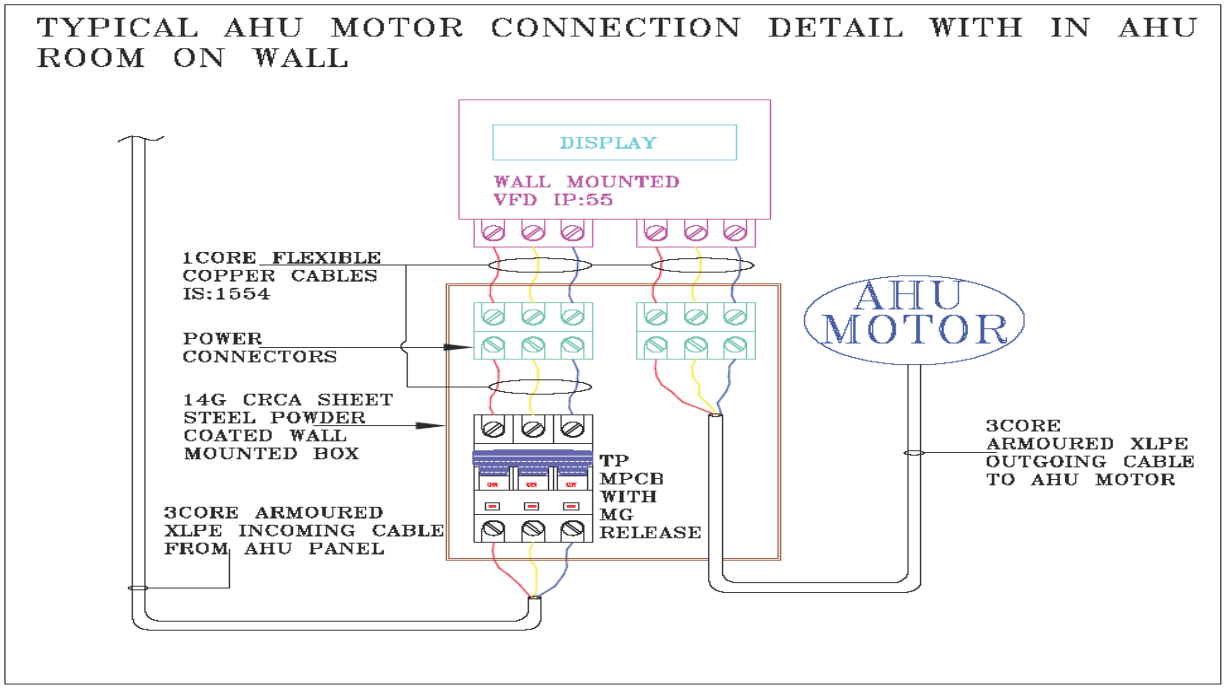
AUTO 'ON' / 'OFF'	(Means remotely through BMS)
HAND 'ON'	(Means 'ON' from drive itself)
RESET	If trip on fault or on fire signal & can be 'Reset' from the Drive only after fault is cleared.

F. SKETCHES


VFD'S
INPUT
VFD WITH INBUILT DC CHOKE
THDI NOT MORE THAN 40%
M
AHU, PUMP, FAN,
MOTOR.
INPUT
VFD WITH 'LC' CIRCUIT PASSIVE FILTER (INBUILT IN VFD)
THDI NOT MORE THAN 25%
M
CHILLER MOTOR
INPUT
ACTIVE HARMONIC FILTER
THDI LESS THAN 5%
VFD
M


AHU VFD'S MINIMUM NUMBER OF 'DI', 'DO', 'AI', 'AO'
& RELAY OUTPUTS
TO 'UV' LIGHT
(NO)
(NC)
(NO)
(NC)
RELAY OUTPUTS
RELAY OUTPUT RELAYS
DUCT PR. SENSOR (VAV BOX)
DUCT PR. SENSOR (VAV BOX)
'AI'
'AI'
AHU VFD
IP55
MOUNTED ON WALL IN AHU ROOM
COMMUNICATION PORT
24V DC SUPPLY
'DI' FIRE SIGNAL FROM FRM
'DI' AHU DOOR LIMIT SWITCH
'AO'
'DI' ON/OFF COMMAND FROM BMS
'DO' AUTO/MANUAL STATUS TO BMS
'DO' AHU RUN STATUS TO BMS
'AI' AHU SPEED MODULATION THRU BMS
'DO' 'DI' 'AI' 'AO'
MINIMUM REQUIREMENT OF I/O'S & RELAY'S OUTPUTS
2 3 or 4 3 or 2 1
RELAY OUTPUTS (NO+NC)
2 (2 NOS. CONTACTS - OUTPUT Relay Each with NO+NC)
(230V, 5Amp, Rated Contacts)
So total 2 NOS + 2 NCs
230V, 5Amp rated contacts
AHU VFD'S TO HAVE MINIMUM OF ABOVE INDICATED 'DI', 'DO', 'AO', 'AI', RELAY CONTACTS OR MORE AS REQUIRED BY THE PROJECT NEED


VFD FOR PRESSURISATION FANS
MINIMUM NUMBER OF 'DI', 'DO', 'AI', 'AO' & RELAY OUTPUTS
VFD INSIDE PANEL
'AO'
'AI'
'AI'
'AI'
'DI'
'DI'
'DO'
'DO'
FIRE SIGNAL
ON/OFF COMMAND FROM BMS
AUTO MANUAL STATUS TO BMS
FAN RUN STATUS TO BMS
RELAY OUTPUTS
SPEED MODULATION THRU BMS
SPEED MODULATION FROM BMS THRU PRESSURE SENSER
COMMUNICATION PORT
'DO' 'DI' 'AO' AI RELAY OUTPUT (NO+NC)
MINIMUM REQUIREMENT OF I/O's & RELAY OUTPUTS
2 2 1 3 4
(2NO + 2NC)
230V, 5Amp rated Contacts


TYPICAL AHU MOTOR CONNECTION DETAIL WITH IN AHU ROOM ON WALL
DISPLAY
WALL MOUNTED VFD IP:55
1CORE FLEXIBLE COPPER CABLES IS:1554
POWER CONNECTORS
14G CRCA SHEET STEEL POWDER COATED WALL MOUNTED BOX
3CORE ARMOURED XLPE INCOMING CABLE FROM AHU PANEL
TP MPCB WITH MG RELEASE
AHU MOTOR
3CORE ARMOURED XLPE OUTGOING CABLE TO AHU MOTOR

19. MOTOR STARTER AND VARIABLE FREQUENCY DRIVE FEEDERS WITH IN MCC's (Motor Control Centre)- SPECIFICATIONS

Type of Motor Starters:

- DOL starters upto 10HP / 7.5 KW motors.
- Star-Delta starters from 12.5HP / 9.3 KW and above.
- VFD's for motors, wherever specified.
- Soft starters / VFD's for fire pumps.

All Starter feeders for **DOL, Star-Delta, VFD and Soft Starter** shall be complete with and inclusive of the following:

DOL starter feeder **upto 7.5 KW / 10HP Motor** shall be complete with and inclusive of the following, but refer specifications for details:

- 3P MPCB with in built Thermal & Magnetic releases.
- MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.
- 3 Pole Contactor (110 V contactor coil voltage).
- A/M selector switch- 2pole/2way (for BMS connectivity)
- ON / OFF Push buttons
- ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts & trip indication from MPCB Aux. contact) with additional trip contact multiplier for BMS.
- Digital Ammeter with inbuilt selector switch and with metering class CT's (Upto 10 HP, only one CT in one of the phases)
- Internal wiring
- Type-II coordination

Star Delta starter feeder **from 9.3KW / 12.5HP and upto 30 KW / 40 HP Motor** shall be complete with and inclusive of the following, but refer specifications for details:

- 3P MPCB with in built Thermal & Magnetic releases.
- MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.
- 3 Pole Contactors (110 V contactor coil voltage). Star, Delta & Main Contactors.
- Timers
- A/M selector switch- 2pole/2way (for BMS connectivity)
- ON / OFF Push buttons
- ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts & trip indication from MPCB Aux. contact) with additional trip contact multiplier for BMS.
- Digital Ammeter with inbuilt selector switch and with metering class CT's (one per phase) (Three CT's)
- Internal wiring
- Type-II coordination

Star Delta starter feeder **from 37 KW / 50HP and upto 110 KW / 150 HP Motor** shall be complete with and inclusive of the following, but refer specifications for details:

- 3P Motor Duty MCCB with inbuilt Fixed Magnetic release.
- 3 Pole Contactors (110 V contactor coil voltage). Star, Delta & Main Contactors.
- Timers
- External Digital Motor protection relay, CT operated (3 Nos. protection class CT's). Motor protection relay to offer protection against thermal O/L, O/C, Under correct, SPP, Locked rotor and earth leakage. Motor Protection relay shall be with current display. Motor protection relay with additional trip contract multiplier for BMS
- A/M selector switch- 2pole/2way (for BMS connectivity)
- ON / OFF Push buttons
- ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts).
- Internal wiring

- Type-II coordination

Star Delta starter feeder **for motors above 110 KW / 150 HP Motor** shall be complete with and inclusive of the following, but refer specifications for details:

- 3P Motor Duty MCCB with inbuilt Microprocessor based release.
- 3 Pole Contactors (110 V contactor coil voltage). Star, Delta & Main Contactors.
- Timers
- External Digital Motor protection relay, CT operated (3 Nos. protection class CT's). Motor protection relay to offer protection against thermal O/L, O/C, Under correct, SPP, Locked rotor and earth leakage. Motor Protection relay shall be with current display. Motor protection relay with additional trip contract multiplier for BMS
- A/M selector switch- 2pole/2way (for BMS connectivity)
- ON / OFF Push buttons
- ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts).
- Internal wiring
- Type-II coordination

All **VFD feeders** shall be complete with and inclusive of the following, but refer specifications for details :

- For Motor Upto 30 KW / 40 HP, 3P MPCB with.
- MPCB'S above 63A shall be with Microprocessor based release.
- For Motor from 37 KW / 50 HP and upto 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Fixed Magnetic release.
- For Motor for above 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Microprocessor based release.
- VFD as per specifications.
- VFD cooling fan (110V)
- Type-II coordination

All **VFD feeders with by-pass starter** shall be complete with and inclusive of the following, but refer specifications for details:

- For Motor Upto 30 KW / 40 HP, 3P MPCB with inbuilt Magnetic release.
- MPCB'S above 63A shall be with Microprocessor based release.
- For Motor from 37 KW / 50 HP and upto 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Fixed Magnetic release.
- For Motor for above 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Microprocessor based release.
- VFD as per specifications.
- VFD cooling fan (110V)
- Bypass starter if called for as described in above starter paragraphs (110V contactor coil voltage). DOL or Star Delta depending upon Motor HP.
- Internal wiring
- Type-II coordination

Soft Starter feeders shall be complete with and inclusive of the following, but refer specifications for details:

- For Motor Upto 30 KW / 40 HP, 3P MPCB with inbuilt Magnatic release.
- MPCB'S above 63A shall be with Microprocessor based release.
- For Motor from 37 KW / 50 HP and upto 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Fixed Magnetic release.
- For Motor for above 110 KW / 150 HP, 3P Motor Duty MCCB with inbuilt Microprocessor based release.
- Thyristar circuit with inbuilt O/L and SPP feature (in case of fire pumps no O/L & SPP protection)
- Bypass contactor to Thyristar circuit (110 V contactor coil voltage)
- A/M selector switch- 2pole/2way (for BMS connectivity)
- ON /OFF push buttons
- Necessary 'DO' & 'DI' ports
- Modbus communication port
- ON /OFF / Trip indications (110V)

- Digital Ammeter with inbuilt selector switch and with metering class CT's (one per phase) (3CT's)
- Internal wiring
- Type-II coordination

Notes:

1. **Soft starter** for fire pumps shall be without O/L relay feature.
2. Soft Starter shall be complete with inbuilt bypass Contactor.

Following motor control centres / panels shall have:

- 3 Pole incomer switch i.e. MCCB or ACB & 3P bus bars
  a. AHU Panel
  b. Basement / podium ventilation panel
  c. Staircase & lift well pressurization fan panel
  d. Smoke venting panel
  e. Chillers auxiliary panel
  f. Chiller plant panel
  g. Plumbing panel
  h. Fire pump panel
  i. Sump pump panel
  j. DG set auxiliary panel

20. MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES IN STANDALONE, INSIDE AHU ROOMS FOR AHU MOTORS & OTHER MOTORS FOR PUMPS & FANS, NEAR MOTORS BUT NOT INSIDE MCC & PANELS

Note: Only 3 Phase supply without neutral shall be available at starter incomer / VFD disconnect switch.

Type of Motor Starters:

- DOL starters upto 10HP / 7.5 KW motors.
- Star-Delta starters from 12.5HP / 9.3 KW and above.
- VFD's for motors, wherever specified.
- Soft starters / VFD's for fire pumps.

a. DOL Starters for motors above upto 10HP / 7.5 KW shall have:

14G CRCA powder coated sheet steel enclosure, wall mount type to house switchgear.

Type-II Co-ordination

MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.

3 Pole Contactor (110 V contactor coil voltage)

A/M selector switch- 2pole/2way (for BMS connectivity)

ON / OFF Push buttons

ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts & trip indication from MPCB Aux. contact) with additional trip contact multiplier for BMS

R,Y,B LED Indications (63.5V)

1 No. cast resin metering Class-1 accuracy CT's of adequate burden & ratio, in one of the phases.

Digital KWH meter + Ammeter – communicable type (110V)

PT for metering & indication lamps:

415V / √3 / 110V / √3 PT for metering and indication lamps.

PT shall be Class-1 accuracy.

PT shall be cast resin type.

• PT shall be of suitable burden (VA) to cater to load of R,Y,B indication lamps (63.5V) at incomer, KWH meter (110V), contactor coils (110V) & ON / OFF / Trip Indications lamps (110V).

Protection for metering PT:

TP MPCB /TP MCB of suitable rating & fault withstand capacity on primary side of PT.

TP MCB of suitable rating on secondary side of PT.

ADDITIONAL FEATURES (FOR AHU MOTORS):

• Cast Resin Copper wound step down transformer, 415V, 3Ph / 230V, 1Ph of suitable 'VA' for AHU's marine light, 'UV' light if asked for and ultrasonic humidifier if asked for in the AHU BOQ.

Transformer to have TPMCB/MPCB & DP MCB at primary & secondary for protection.

DP MCB's for protection of 230V, 1Ph. AC marine light & 'UV' light & ultrasonic humidifier within AHU.

230V, AC Door Relay with 2 NO + 2NC contacts for AHU Door with DP MCB for protection. Relay for control of lights through door limit switch.

b. Star-Delta Starter from 12.5HP / 9.3 KW to 40HP / 30 KW shall have:

14G CRCA powder coated sheet steel enclosure, wall mount type to house switchgear.

Type-II Co-ordination
MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.
3 Pole Contactors (110 V contactor coil voltage). Star, Delta & Main Contactors.
Timers
A/M selector switch- 2pole/2way (for BMS connectivity)
ON / OFF Push buttons
ON /OFF / Trip indications (110V) (ON /OFF Indication from contactor's 2NO / 2NC Aux. Contacts & trip indication from MPCB Aux. contact) with additional trip contact multiplier for BMS.

R,Y,B LED Indications (63.5V)

3 Nos. cast resin metering Class-1 accuracy CT's of adequate burden & ratio, one in each phase.

Digital KWH meter + Ammeter – communicable type (110V)
PT for metering & indication lamps:
415V / √3 / 110V / √3 PT for metering and indication lamps.
PT shall be Class-1 accuracy.
PT shall be cast resin type.
• PT shall be of suitable burden (VA) to cater to load of R,Y,B indication lamps (63.5V) at incomer, KWH meter (110V), contactor coils (110V) & ON / OFF / Trip Indications lamps (110V).

Protection for metering PT:
3P MPCB of suitable rating & fault withstand capacity on primary side of PT.

3P MCB of suitable rating on secondary side of PT.

ADDITIONAL FEATURES (FOR AHU MOTORS):

Cast Resin Copper wound step down transformer, 415V, 3Ph / 230V, 1Ph of suitable 'VA' **for AHU's Marine light, UV light & ESP filter if asked for.**

Transformer to have TPMCB/MPCB & DP MCB at primary & secondary for protection.

DP MCB's for protection of 230V, 1Ph. AC Marine light, **'UV' light & ESP filter if asked for.**

230V, AC Door Relay with 2 NO + 2NC contacts for AHU Door with DP MCB for protection. Relay for control of lights through door limit switch.

c. VFD for motors upto 40HP / 30 KW shall have:

For Motor Upto 30 KW / 40 HP, 3P MPCB with inbuilt Magnetic release.
MPCB'S above 63A shall be with Microprocessor based release.

MPCB in 14G CRCA powder coated sheet steel enclosure, wall mount type to house switchgear & input / output power connectors.

Input / Output cable terminals of suitable rating.

Suitable rated IP55 VFD, Wall Mounted, outside the enclosure.

ADDITIONAL FEATURES (FOR AHU MOTORS):

• Cast Resin Copper wound step down transformer, 415V, 3Ph / 230V, 1Ph of suitable 'VA' for AHU's marine light, 'UV' light if asked for and ultrasonic humidifier if asked for in the AHU BOQ.

Transformer to have TPMCB/MPCB & DP MCB at primary & secondary for protection.

• DP MCB's for protection of 230V, 1Ph. AC marine light & 'UV' light & ultrasonic humidifier within AHU.

230V, AC Door Relay with 2 NO + 2NC contacts for AHU Door with DP MCB for protection. Relay for control of lights through door limit switch.

Interconnecting FRLSH Copper cabling as per IS 694 between MPCB output terminal to VFD & from VFD output terminals to output terminal block as per motor HP.

All these items in the same enclosure along with 3P MPCB.

d. VFD with bypass DOL Starter (110V contactor coil voltage):

14G CRCA powder coated sheet steel enclosure, wall mount type to house switchgear & VFD.

All items as listed in DOL Starter for motors for the applicable motor HP as specified in earlier paragraphs along with VFD & by pass scheme of contactors (Two isolation contractors + DOL starter (Contactor) complete in all respects as per specifications. VFD shall be IP20

ADDITIONAL FEATURES (FOR AHU MOTORS):

• Cast Resin Copper wound step down transformer, 415V, 3Ph / 230V, 1Ph of suitable 'VA' for AHU's marine light, 'UV' light if asked for and ultrasonic humidifier if asked for in the AHU BOQ.

Transformer to have TPMCB/MPCB & DP MCB at primary & secondary for protection.

• DP MCB's for protection of 230V, 1Ph. AC marine light & 'UV' light & ultrasonic humidifier within AHU.

230V, AC Door Relay with 2 NO + 2NC contacts for AHU Door with DP MCB for protection. Relay for control of lights through door limit switch.

e. VFD with bypass Star Delta Starter (110V contactor coil voltage):

14G CRCA powder coated sheet steel enclosure, wall mount type to house switchgear & VFD.

All items as listed in Star Delta Starter for motors for the applicable motor HP as specified in earlier paragraphs along with VFD & by pass scheme of contactors (Three isolation contractors + Main, star & Delta (Contactors) complete in all respects as per specifications. VFD shall be IP20.

ADDITIONAL FEATURES (FOR AHU MOTORS):

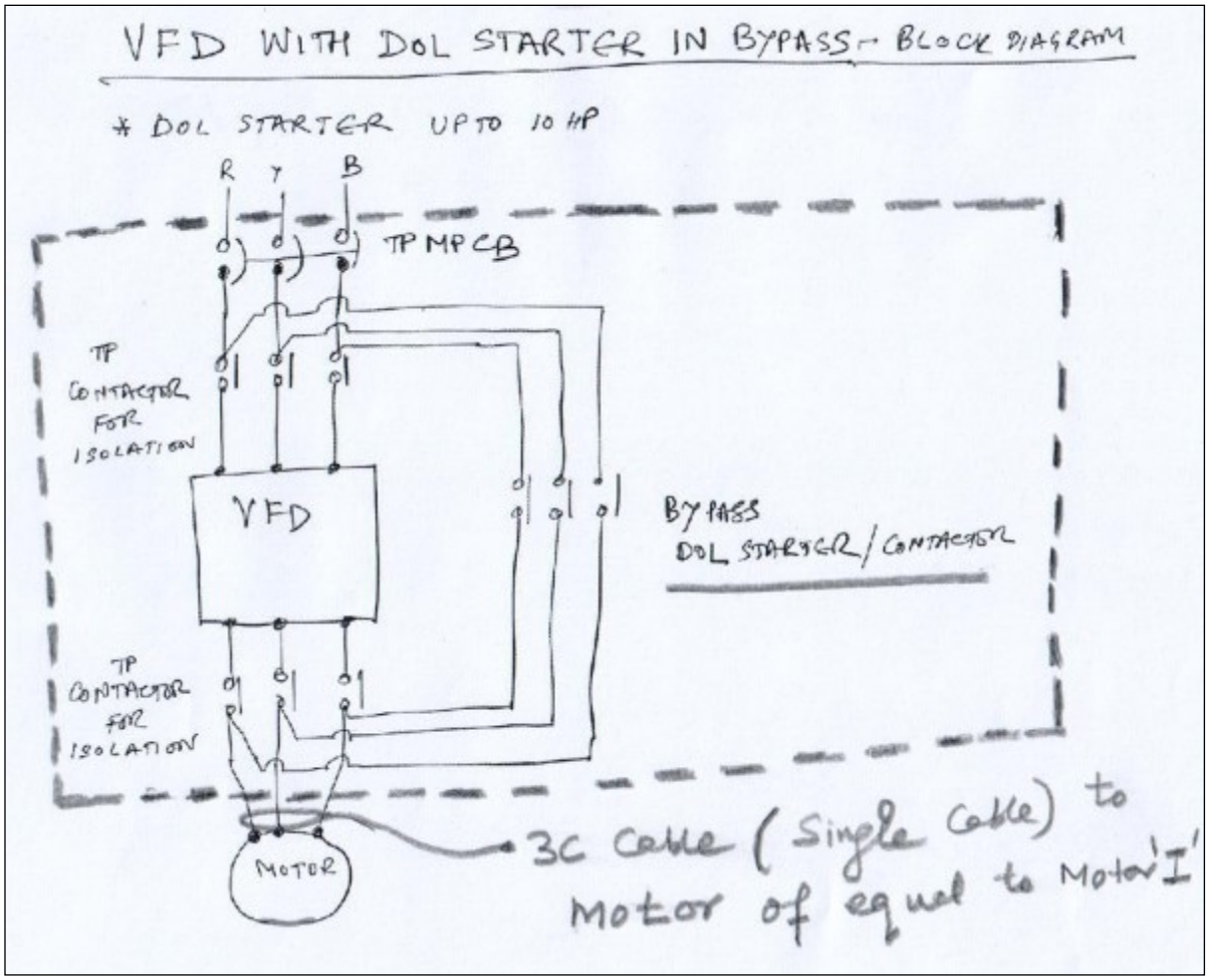
• Cast Resin Copper wound step down transformer, 415V, 3Ph / 230V, 1Ph of suitable 'VA' for AHU's marine light, 'UV' light if asked for and ultrasonic humidifier if asked for in the AHU BOQ.

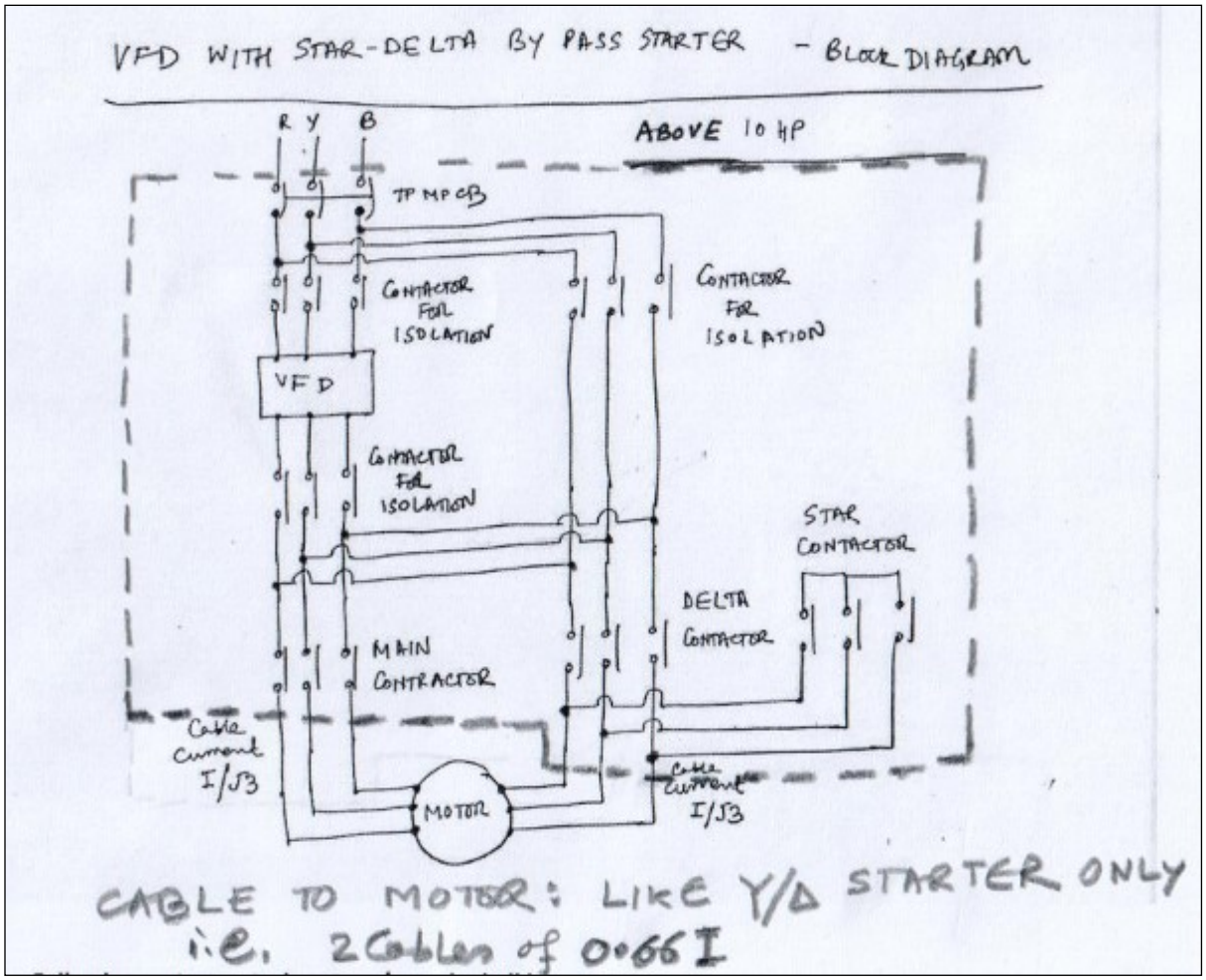
Transformer to have TPMCB/MPCB & DP MCB at primary & secondary for protection.

• DP MCB's for protection of 230V, 1Ph. AC marine light & 'UV' light & ultrasonic humidifier within AHU.

230V, AC Door Relay with 2 NO + 2NC contacts for AHU Door with DP MCB for protection. Relay for control of lights through door limit switch.

Note:- Please refer Block diagram sketches of VFD with by pass starter.


VFD WITH DOL STARTER IN BYPASS - BLOCK DIAGRAM
* DOL STARTER UPTO 10 HP
R
Y
B
TP MPCB
TP CONTACTOR FOR ISOLATION
VFD
BY PASS DOL STARTER / CONTACTOR
TP CONTACTOR FOR ISOLATION
MOTOR
3C Cable (Single Cable) to Motor of equal to Motor 'I'



Following motor control centres / panels shall have:

- 3 Pole incomer switch i.e. MCCB or ACB & 3P bus bars
  a. AHU Panel
  b. Basement / podium ventilation panel
  c. Staircase & lift well pressurization fan panel
  d. Smoke venting panel
  e. Chillers auxiliary panel
  f. Chiller plant panel
  g. Plumbing panel
  h. Fire pump panel
  i. Sump pump panel

21. SOFT STARTER:

- Soft starter shall be used to limit the starting inrush current of motors.
- Soft starter shall have Thyristor to limit the starting current.
- As the motor attains its full speed, the motor running is shifted to a by-pass contactor, which is part of the soft starter assembly.
- Soft starter will have inbuilt overload and single phasing protection.
- Soft starter shall have RS485 (Modbus) communication port.
- Soft starter shall also have programmable DO & DI (Digital Output & Input) ports, as required.
- Soft starter shall be complete with motor duty MPCB or MCCB as incomer or HRC Fuses for short circuit protection and isolation purposes to attain Type-2 coordination.
- Soft starter shall be complete with local ON / OFF push buttons and A/M selector switch.
- For fire pumps, if soft starters are used, then it's overload / over current feature will be kept disabled.

- Soft starter shall have panel door mounted display unit for display of Electrical parameters & ON / OFF / Run status.
- Soft starter shall be integrated with fire alarm system and BMS system.

22. IMPORTANT NOTES FOR ELECTRICAL PANELS, SWITCHGEAR & MOTOR CONTROL CENTRES

- SWITCHGEAR OF ONLY ONE MAKE / MANUFACTURER TO BE USED.
- TYPE-2 CO-ORDINATION TO BE FOLLOWED.
- ICS = ICU = 100% FOR THE MCCB'S, MPCB'S & ACB'S

- **415V/√3/ 110V / √3 POTENTIAL TRANSFORMER FOR INCOMER METERING & R,Y,B PHASE INDICATION LAMPS:-**
  - For Panels/ MCC's (Motor Control Centre's) / PCC's (Power control center) incomer metering & Phase indication R,Y,B lamps, **415V/√3/ 110V / √3 Cast resin PT's shall be used.**
  - Entire metering / MFM's / KWH meters / VAF meters etc, 110V, 3 Phase input.
  - R,Y,B Phase indication lamps shall be 110V/√3 = 63.5V.

- **415V/110V CONTROL TRANSFORMER FOR CONTACTOR COILS & ON/OFF/TRIP INDICATION LAMPS:-**
  - For MCC's (Motor Control Center's), **415 V / 110V Cast resin control Transformers** shall be used for **Control Supply to Contactor Coils and ON/OFF/TRIP indication Lamps**.
  - Contactor Coils of Motor Starters shall be of 110V. **A 110V Control BUS shall be run throughout MCC** to Power 110 V control Transformer of Contactors / Starters.
  - CRITICAL PANELS / MCC's SUCH AS BASEMENT & PODIUM VENTILATION PANEL, PRESSURIZATION FAN PANEL, SMOKE VENTING PANEL & FIRE PUMP PANELS SHALL HAVE TWO CONTROL TRANSFORMERS OF 415V / 110V (ONE TO ACT AS STAND BY) FOR WORKING & STANDBY 110V CONTROL BUS AS REDUNDANCY.

- MOTORISED (EDO) ACB'S SHALL HAVE CLOSING COIL, SHUNT TRIP COIL & UNDER VOLTAGE RELEASE.
- MANUAL (MDO) ACB'S SHALL HAVE SHUNT TRIP COIL.
- ACB'S UPTO 4000A SHALL BE SINGLE FRAME TYPE.
- ALL ACB's OF ALL RATINGS, MANUAL & MOTORISED SHALL BE OF DRAW OUT TYPE.
- MCCB'S WITH FIXED THERMAL & MAGNETIC RELEASES, WHEREVER CALLED FOR, CAN ALSO BE WITH ADJUTABLE THERMAL & FIXED MAGNETIC, IF THIS COMES AS A STANDARD FEATURE OF THE PRODUCT.
- MCCB's UPTO 250A SHALL BE WITH FIXED RELEASES & ABOVE 250A SHALL BE WITH MICRO PROCESSOR BASED RELEASES.
- MOTOR DUTY MPCB'S & MCCB'S TO BE SELECTED AS PER SWITCHGEAR MANUFACTURER'S RECOMMENDATION / CHARTS.
- IN CASE OF ANY DISCREPANCY BETWEEN SPECIFICATIONS, BOQ & DRAWING (SLD), THE BEST OF THE THREE TO BE CONSIDERED OR CLARIFICATION TO BE SOUGHT FROM THE CONSULTANT / CLIENT / PMC.
- TEMPERATURE DERATION OF SWITCHGEAR TO BE TAKEN INTO ACCOUNT WHILE SELECTING IT EVEN IF IT IS NOT ACCOUNTED FOR IN THE BOQ / DRAWING (SLD).
- MOTOR DUTY MCCB'S ARE AVAILABLE IN 50KA FAULT WITHSTAND CAPACITY, EVEN IF IT IS SPECIFIED OTHERWISE IN BOQ / DRAWINGS (SLD).
- MPCB'S LESS THAN 36KA FAULT WITHSTAND CAPACITY NOT TO BE USED, EVEN IF IT HAS BEEN SPECIFIED OTHERWISE.
- STANDARD RANGE OF MCCB'S IS:
  16A, 25A, 32A, 40A, 50A, 63A, 80A, 100A, 125A, 160A, 225A, 250A, 320A, 400A, 500A, 630A
- STANDARD FAULT WITHSTAND RATINGS OF MCCB'S ARE:
  16KA, 25KA, 35KA/36KA, 50KA, 65KA/70KA, 100KA
  STANDARD MPCB'S FAULT WITHSTAND RATINGS ARE:
  25KA, 36KA, 50KA, 100KA, 150KA

- MPCB'S UPTO 63A SHALL BE THERMAL-MAGNETIC TYPE WITH ADJUSTABLE O/L TRIP SETTING AND ABOVE 63A SHALL BE WITH MICROPROCESSOR BASED RELEASE.
- ALL MCCB'S & MPCB'S SHALL BE WITH DIRECT / EXTENDED ROTARY HANDLES.
- ARRANGEMENT OF PAD LOCKING & FOOL PROOF LOTO (LOCKOUT & TAG OUT) TO BE AVAILABLE WITH ALL MCCB'S & MPCB'S FOR MAINTENANCE, SERVICING, REPAIRS AND INSPECTION FOR SAFETY REASONS ON MOTORS / EQUIPMENT. ALSO, DOOR INTERLOCK DEFEAT FUNCTION SHOULD NOT BE PROVIDED.
- CLIENT's MAINTENANCE TEAM TO UTILIZE LOTO FEATURE BEFORE INITIATING ANY REPAIR / MAINTENANCE ON ALL ELECTRICAL EQUIPMENT / PUMPS / MOTORS / FANS / BLOWERS ETC.

- **ATS**

  For Main LT Panel, Fire Emergency Panel & DG Set Aux. Panel:
  - ATS shall be ASCO Make Series 7000 for above 1200Amps and Series 300 below 1200 Amps or equivalent.
  - Main LT Panel & Fire Emergency Panel shall have 4P ATS.
  - DG Set Aux. Panel shall have 3P ATS.
  - ATS with controller, controller will AMF function.
  - ATS with 100% overlapping neutral.
  - ATS: Solenoid operated, RS485 Communication.
  - Utilization category: AC 33A.
  - Same phase angle transition & in phase monitoring.
  - 85KA for 0.3 sec (fault withstand)

  For Lift Panel & UPS Input Panel:
  - ATS shall be ASCO Make Series 300 or equivalent
  - 4P ATS
  - ATS with 100% overlapping neutral.
  - ATS: Solenoid operated.
  - 85KA for 0.3 sec (fault withstand).

- CHILLER AUX. PANEL, AC PLANT / CHILLER PLANT PANEL, PRIMARY / SECONDARY PUMP VFD PANEL, PLUMBING PANEL, STP PANEL, FIRE PUMP PANEL, AHU PANEL, BASEMENT VENTILATION PANEL, SMOKING VENTING PANEL, AIR WASHER PANEL, SCRUBBER PANEL, JET VENT PANEL, PRESSURIZATION FAN PANELS AND ALL MOTOR CONTROL CENTRES WILL NOT HAVE ANY NEUTRAL BUS BAR AND ONLY 3C CABLE SHALL BE TERMINATED IN MOTOR CONTROL CENTRES.
- ALL METERING, PROTECTION, INDICATION LAMPS ETC. SHALL BE OF 110V i.e. 230V SUPPLY SHALL NOT BE USED FOR THESE PURPOSES & PANEL DOOR WILL NOT HAVE 230V METERING & LAMPS ETC.
- CONTACTOR'S COIL SHALL BE 110V, AC. NECESSARY PT'S TO BE USED.
- SWITCHGEAR SELECTION SHOULD ACHIEVE DISCRIMINATION EVEN IF IT IS NOT SHOWN IN BOQ / DRAWING (SLD).
- BURDEN CALCULATIONS FOR CT'S, PT'S AND CONTROL TRANSFORMERS TO BE SUMITTED ALONG WITH SHOP DRWINGS.
- INCOMER SWITCHGEAR, BUS BARS, SUPPORTS AND OUTGOING SWITCHGEAR SHALL BE OF SAME FAULT LEVEL WITHSTAND CAPACITY AS MENTIONED FOR THE PANEL.
- SUGGESTED "MCCB" SELECTION FOR CAPACITOR APPLICATION WITH DETUNED FILTERS:-

5 KVAR	16A TP MCCB (TH + MG) – F
10 KVAR	25A TP MCCB (TH + MG) – F
15 KVAR	40A TP MCCB (TH + MG) – F
20 KVAR	50A TP MCCB (TH + MG) – F
25 KVAR	63A TP MCCB (TH + MG) – F
50 KVAR	125A TP MCCB (TH + MG) – F

- CAPACITORS SHALL BE HEAVY DUTY MPP CONSTRUCTION.
- 7% & 14% DETUNED REACTORS SHALL BE COPPER WOUND, CLASS H INSULATION.
- **DEDICATED COPPER EARTHING LINK OF SUITABLE SIZE ON INSULATED SUPPORTS FOR:**
  ALL UPS DB'S, PDU'S, UPS OUTPUT PANELS & FLOOR UPS PANELS/ SDB - UPS PANELS WILL HAVE A DEDICATED COPPER EARTH LINK OF ADEQUATE SIZE SUPPORTED ON INSULATED SUPPORTS FOR 3RD PIN EARTHING (ISOLATED GROUND).
  THE GROUNDING EARTH LINK SHALL ALSO BE PROVIDED IN ADDITION TO DEDICATED EARTH BUS.

MOTOR FEEDERS

A. MOTOR FEEDERS WITH STARTERS:-

1. Upto 10 HP / 7.5 KW Motor

- 3P MPCB – TH + MG (Thermal Magnetic Release with adjustable O/L trip class).
- MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.
- DOL

2. From 12.5 HP / 9.3 KW to 40 HP / 30 KW Motors

- 3P MPCB – TH + MG (Thermal Magnetic Release with adjustable O/L trip class).
- MPCB'S upto 63A shall be Thermal-Magnetic type with adjustable O/L trip setting and above 63A shall be with Microprocessor based release.
- Star Delta

3. From 50 HP / 37 KW to 150 HP / 110 KW

- 3P MCCB – M (F) (Motor Duty – Fixed Release)
- Star Delta
- External Electronic O/L Relay with SPP

4. Above 150 HP / 110 KW Motors

- 3P MCCB – MP (Motor Duty – Micro Processor Base Release)
- Star Delta
- External Electronic O/L Relay with SPP

B. MOTOR FEEDERS WITH VFD's

1. Upto 40 HP / 30 KW Motors

- 3P MPCB –MG (Magnetic Release)
- MPCB'S upto 63A shall be Magnetic release and above 63A shall be with Microprocessor based release.
- VFD

2. From 50 HP / 37 KW to 150 HP / 110 KW Motors

- 3P MCCB –M(F) (Motor Duty - Fixed Release)
- VFD

3. Above 150 HP / 110 KW Motors

- 3P MCCB – M (MP) (Motor Duty – Micro Processor Base Release)
- VFD

C. MOTOR FEEDERS WITH SOFT STARTERS

1. Upto 40 HP / 30 KW Motor

- 3P MPCB – MG (Magnetic Release)
- MPCB'S upto 63A shall be Magnetic release and above 63A shall be with Microprocessor based release.
- Soft Starter with inbuilt Bypass Contactor

2. From 50 HP/ 37 KW to 150 HP / 110 KW Motor

- 3P MCCB – M(F) (Motor Duty - Fixed Release)
- Soft Starter with inbuilt Bypass Contactor

3. Above 150 HP / 110 KW Motor

- 3P MCCB – M (MP) (Motor Duty – Micro Processor Base Release)
- Soft Starter with inbuilt Bypass Contactor

D. JET FAN 2 STAGE STARTER

- 3P MPCB – MG (Magnetic Release)
- 2 Stage Starter
- Overload Relay & SPP

IMPORTANT NOTE: - *VENDORS TO SUBMIT SWITCHGEAR SELECTION/ RATINGS FOR ALL THE PANELS ALONG WITH THE BID.*

23. CONSTRUCTION FEATURES & GENERAL NOTES OF LOW VOLTAGE MAIN AND SUB DISTRIBUTION BOARDS / PANELS/SWITCH BOARDS/ METER BOARDS/ACB ISOLATOR PANELS / MOTOR CONTROLS CENTRES (MCC)

GENERAL SPECIFICATIONS

Main & Sub Distribution Boards shall be classified as per IEC: 61439 of Cubicle type, Sheet steel clad, Totally enclosed, Dust & Vermin proof, Indoor type/ out door type, Rigid, Free standing, Floor mounted compartmentalized, Single front for use on 415 volts, 3 phase, 50 cycles, AC system with a fault level withstand capacity as per B.O.Q. /as required, RMS Symmetrical. Complete with busbars interconnections, power, control/auxiliary circuits/ wiring & earthing, with switchgear as per B.O.Q of approved makes as specified.

ALL PANELS / DISTRIBUTION BOARDS EXCEPT FEEDER PILLERS, WALL MOUNT PANELS AND OUT DOOR PANELS SHALL BE AS PER IEC: 61439 TESTED (TOTAL ASSEMBLY). IT SHALL MEAN BLOCKSET WITH SCHNEIDER SWITCHGEAR, R2K WITH ABB SWITCHGEAR, C-PAN WITH SIEMENS SWITCHGREAR AND TIA / TERA FOR L&T SWICHGEAR IF SPECIFIED.

BASE FRAME: 3MM

Normal Indoor Application: CRCA WITH POWDER COATING (minimum 60 micron coating).
Outdoor Application: ALUZINC WITH POWDER COATING (minimum 80 micron coating).
CRCA Sheet Type: PN02/ Equivalent as approved.
CRCA Sheet Make: TISCO/ Equivalent as approved.
ALUZINC Sheet Type: Grade CS Type A.
ALUZINC Sheet Make: Dongbu Steel South Korea.

STRUCTURE, COVER BACK & FRONT DOOR: 2MM

Normal Indoor Application: CRCA WITH POWDER COATING (minimum 60 micron coating).
Outdoor Application: ALUZINC WITH POWDER COATING (minimum 80 micron coating).
CRCA Sheet Type: PN02/ Equivalent as approved
CRCA Sheet Make: TISCO/ Equivalent as approved
ALUZINC Sheet Type: Grade CS Type A.
ALUZINC Sheet Make: Dongbu Steel South Korea.

INTERNAL PARTITIONS: 1.6MM

Normal Indoor Application: ALUZINC
Outdoor Application: ALUZINC
ALUZINC Sheet Type: Grade CS Type A.
ALUZINC Sheet Make: Dongbu Steel South Korea.

CABLE GLAND PLATES: 3MM

Multi Core Cables: ALUZINC

Single Core Cables: Aluminum

INTERNAL SWITCHGEAR MOUNTING PLATES: 2MM
Normal Indoor Application: ALUZINC
Outdoor Application: ALUZINC
ALUZINC Sheet Type: Grade CS Type A.
ALUZINC Sheet Make: Dongbu Steel South Korea.

CONSTRUCTION

- Completely modular & compartmentalized, form 3B separation. Separate adequately spaced Unit Chamber, Bus bar & cable compartments.
- IP20 ingress protection to be ensured compartment to compartment inside the panel.

EXTENSIBILITY
Readily extensible on both ends.
Panels should be made in easily transportable sections.

DIMENSIONS

Operating height	1800mm max. 300mm min.
Overall height	2400mm max.
Compartment size HXW	225mm x 500mm min
Cable chamber	300mm min.

DEGREE OF PROTECTION
IP: 42 for totally Indoor application.

- Panels in Substation area, Electrical Rooms, LT Panel Rooms & DG Set Room
- MDB L+P Panel
- Tower Panel, Tower LT Panel (individual housing tower or office tower panel)
- EWS Panel
- Meter Boards (In Electrical Rooms)
- Lift Panel (In Lift Machine Room)
- AHU Panel
- Basement Ventilation Panel
- Staircase & Liftwell Pressurization Fan Panel (If Indoors)
- Plumbing Panel
- Fire Pump Panel
- STP Panel
- AC / Chiller Panel
- Chiller Auxiliary Panel
- DG Set Auxiliary Panel

- **IP: 54 for Indoor Application**
- Laundry Panel
- Kitchen Panel
- Sump pump panel

IP: 55 for Outdoor Application.

- Feeder Pillar
- Outdoor Junction boxes
- Outdoor boards / panels/Outdoor DG Panel
- ACB/MCCB Isolators (outdoors)

All outdoor IP 55 panels shall be:
a. Double door design

b. With canopy
c. Panel shall have forced ventilation mechanism with Rital fan & filter section, to avoid temperature rise and at the same time maintaining IP 55 integrity.
d. Complete ALUZINC Powder coated construction. 80 microns powder coating.

DOOR HINGES
Concealed, Powder Painted

DOOR LOCKS
Zinc alloy powder painted with provision for pad locking.

GASKET
Neoprene / PE foam of suitable profile to provide desired degree of protection.

LIFTING ARRANGEMENT
Eye bolt of removable design, when removed these shall not leave any opening in the boards.

PAINTING
Pre-treatment eight tank process on CRCA sheets or on-line automatic spray system with oven for drying after Pre-treatment as per IS: 101-1988 effective temperature and concentration control. Powder coating of desired shade as per requirement. Paint thickness min. 60 micron

CORROSSION RESISTANCE
Withstand 500 hrs of Salt Spray as per IS: 101-1988

BUS BARS MAIN
Aluminum E-91E grade, min. 53% IACS
Copper min 99% IACS (Tinned copper)
Configuration: Interleaved 2000A & above

Minimum clearances shall be:

Phase to Phase		32mm
Phase to Neutral	25mm	
Phase to earth		25mm
Neutral to earth	25mm	

BUS BARS EARTH
As per material of main busbar of size suitable to withstand fault level specified / as required. Continues length of earth bus to be provided.

UPS Output Panels shall have two earth bars of tinned copper of suitable rating. One of the earth buses shall be dedicated i.e. mounted on insulated supports.

BUS BAR TEMP. RISE
Ambient 45^{o}C
Maximum bus bar temperature rise 40^{o} C over ambient
No deration of Switchgear & Panels upto 45^{0}C

BUS BAR SIZING / CROSS-SECTION
Bus bars to be sized to carry the full rated load current without exceeding maximum temperature rise as limited above. Bus bar size calculations to be submitted with shop drawings. Busbars to withstand the maximum short circuit current as specified / as per requirement.

BUS BAR SUPPORTS
Non Hygroscopic Epoxy/SMC/Nylon 6.6 supports at suitable distance to withstand forces of short circuit as per requirement.

BUS BAR INSULATION
Black heat shrinkable, fire retardant, self extinguishing type sleeves suitable to withstand 110°C
Colour coding to be followed as per IS codes. Phase sequences and polarity to be followed as per IS codes.

SHROUDING
All live parts should be shrouded with IP2 protection Fire Retardant, Non Inflammable, Non Hygroscopic e.g. Polycarbonate, FRP.
BUS BAR SLEEVING
Heat shrinkable sleeves rated for minimum 110 deg C for one hour.

HARDWARE

A. For Internal Connections of switch gear, bus bars & cables etc.

- High Tensile MS Alloy, Zinc coated, Grade 8.8 (Minimum 10 micron coating thickness). (Trivalent Plating CR3+).
- Salt Mist spray test with stand: 120 Hours duration.

1.	Steel Hardware		
	Salt mist spray withstand	:	120 Hours
	Bolt and nuts		
	Hardware quality	:	8.8
	According to	:	EN 20898, EN ISO 3506-1, 4759-1 (=S=FT30860)
	Contact Washers		
	Washer quality	:	8.8
	Class	:	160 HV
	According to	:	EN 20898, EN ISO 3506-1, 4759-1

Note: Contact washer to be fixed on both sides (Plain Washer & Spring Washer).

B. For External Body & Enclosure Construction: High Tensile MS Alloy, Zinc Coated Grade 8.8 (minimum 10 micron coating thickness). (Trivalent Plating CR3+).

PANEL COOLING / VENTILATION:
110V 1phase, heavy duty/ sturdy, panel ventilation fans to be employed, which shall be controlled by a thermostat. Or in VFD motor modules, module ventilation fan to be linked with VFD operation i.e. "On" operation of fan through relay contacts of the VFD , so that ventilation fan for VFD will be "On "only when the particular VFD is "On". Relay contacts of any VFD are suitable for 230V, so 110V will not be any problem.

PANEL SPACE HEATING /CONDENSATION CONTROL:
230V or 415V space heaters with humidistat to be employed for moisture condensation control.

WIRING
1100V Fire retardant, virgin PVC color coded flexible wire

Voltage circuit	1.5 sq mm
Current circuit	2.5 sq mm
Earth circuit	2.5 sq mm

As per IS: 694

WIRING IDENTIFICATION
Computerized ferrule on both ends as per IS: 375

TERMINAL BLOCK
Power - Melamine stud type.

Control - Polyimide color coded screw less clamp fit type.
Not more than one wire connected to one terminal block.
Plug in type terminal block at each transport section.

COMPONENT LEGEND
Computerized labels for all control component & terminal block

FEEDER DESCRIPTION PLATES
Powder coated Al. Plate with computerized printing, size:
MDB = 150 x 50 min
S/DB = 100 x 40 min

SPARE FEEDERS
It shall be as per B.O.Q. / SLD. If B.O.Q / SLD does not specify anything, than an average of 20% of a mix of various ratings / feeders to be provided as spare feeders in each board / panel. Spare feeders must include a minimum one biggest and a minimum of one smallest rated feeders as spares along with other spares.

CABLING
Provision for top/ bottom/ top & bottom entry of cables, as per requirement / as per site. Adequately sized cable chambers. Easy and safe termination & maintenance facility.

BUS TRUNKING TERMINATION
Wherever specified in B.O.Q power connection arrangement at top suitable for bus trunking.

SWITCHGEAR
As per specification & Makes specified. IS: 13947 I- IV, 1993
Only one make of switchgear to be used in a board/panel. The switchgear selection shall be as per manufacturer's co-ordination tables. Type 2 coordination to be achieved as a minimum.

CONTROL MCB'S / MPCB'S
For control and metering circuit/wiring, these shall be of fault level as required.
CONTROL COMPONENTS
As per specification & Makes specified. IS: 13947 I - IV, 1993

INDICATING INSTRUMENTS
Analog/Digital as per specifications, notes, B.O.Q. & Makes specified. IS: 13779

BMS compatible multifunction meters shall be complete with communication card, shall be net-workable and shall be wired on to common RS 485 Bus and information from these meters to BMS to be released at one point.

INDICATING INSTRUMENTS ACCESSORIES
CT/PT-Cast resin as per specifications & make specified. IS: 2705, 1992

SPACE HEATER
All ACB Incomer & bus couplers shall be provided with Space Heater & Thermostat & 11 watt panel illumination. Heaters shall be controlled by a 6A MCB / MPCB as per the required fault level.

PLC'S FOR LOAD MANAGEMENT & INTERLOCKING OF BREAKERS:
Use separate PLC's for Load management and for separate for interlocking of breakers and bus couplers and closing of bus couplers.

SHOP DRAWINGS

Notes, General arrangement, Elevations, Single line diagram, Bill of material, Control and inter locking scheme to be submitted for approval prior to manufacturing and approval taken from PMC / Consultant / Owner.

TESTING & PRE-DISPATCH QUALITY CONTROL

A. Fabrication, Pre-treatment, painting, assembly and wiring.

B. **Tests**:

- Physical, Electrical, and Operational tests of all Breakers / Switches.
- Operational check of all meters and relays.
- Dielectric strength test for insulation at 2.5kV for 1 sec.
- Insulation resistance test at 1000V megger,
- Protective measures and continuity of circuits, as per IS: 8623-I, 1993.
- Testing of protection relays by secondary injection kit before commissioning.
- Interlocking Function Test.
- Earth continuity test between various Non-current carryings parts of equipment steel work etc. & the earth bus provided in the panel.

INSPECTION

To be offered at works to PMC / Owner.

TEST CERTIFICATE TYPE AND ROUTINE

Test results for routine tests conducted at works should be submitted. Type tests as per IS: 61439.

PACKING

Wooden Crates/ Wooden Cases/ Polythene & Water proof paper to be used.

AS MANUFACTURED DRAWINGS

To be submitted in CD format with catalogues and test certificates of switchgear, controlgear and other components used within MDB & PDB.

AFTER SALES SERVICE

Manufacturer to have an Independent department to render after sales support for Installation, commissioning & trouble shooting during and after warranty period.

OPERATING CONDITIONS:

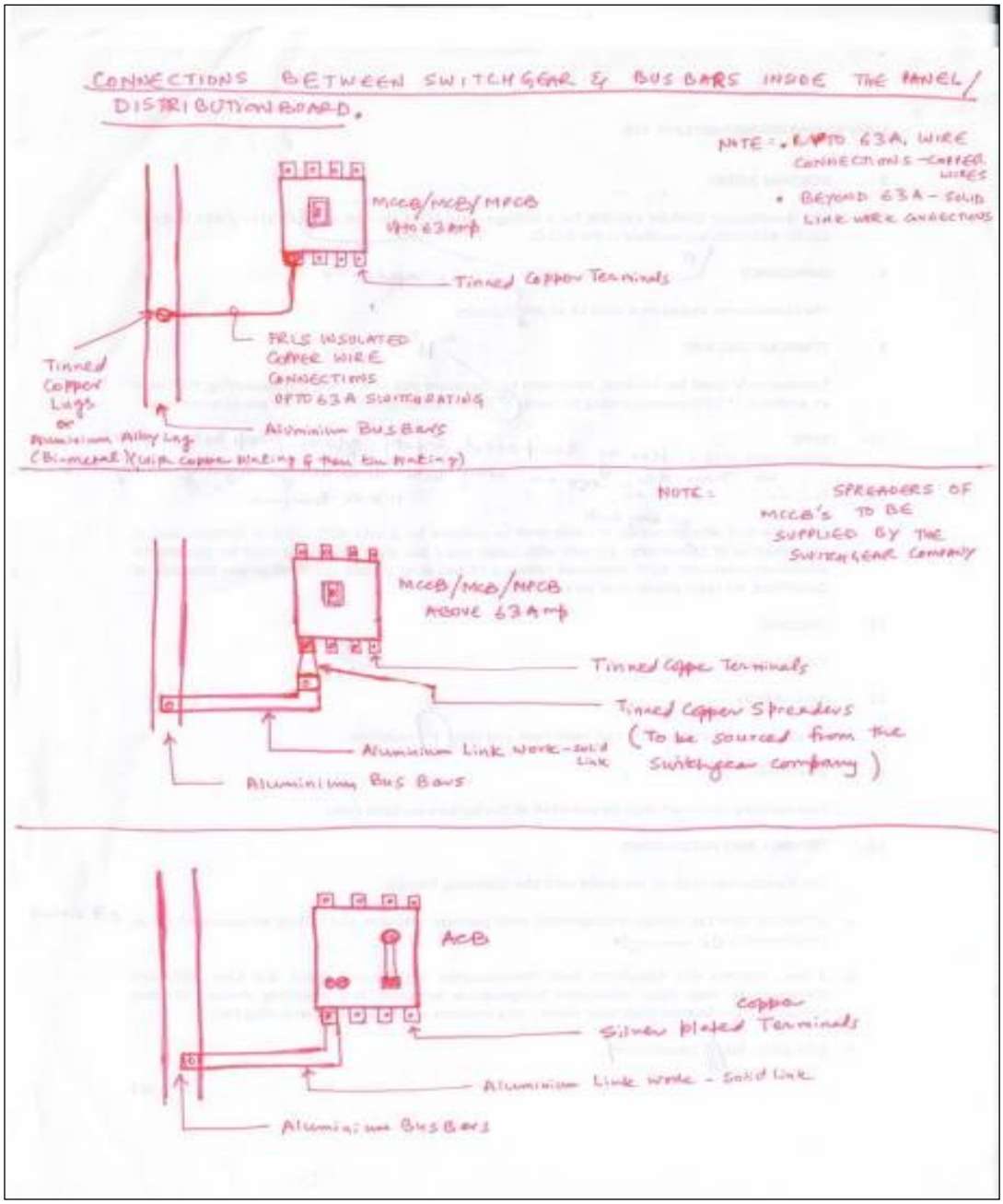
- No De-ration of panels, Switchgear/Equipment & Busbars upto 45 Deg. C & Altitude of 1000M above MSL for indoor panels**.**
- No De-ration of panels, Switchgear/Equipment & Busbars upto 50 Deg. C & Altitude of 1000M above MSL for outdoor panels / feeder pillars.

CONNECTION BETWEEN BUSBARS & SWITCHGEAR

- Upto 63Amp Switch rating with 1.1 KV grade FRLS PVC insulated flexible single core copper cables. Tinned copper or silver plated copper lugs shall be used on copper wires.
- Above 63Amp Switch rating, with solid aluminium / copper busbar links, to be used.
- Neutral Bus bars for four pole feeders shall be of the same size as phase.
  Neutral Bus bars for triple pole feeders shall be of 50% size of phase.
  Neutral Bus bars for UPS panels shall be of 200% size of phase.

ROTARY HANDLES & LOTO FEATURES IN MCCB'S & MPCB'S:

- ALL MCCB'S & MPCB'S SHALL BE WITH DIRECT / EXTENDED ROTARY HANDLES.
- ARRANGEMENT OF PAD LOCKING & FOOL PROOF LOTO (LOCKOUT & TAG OUT) TO BE AVAILABLE WITH ALL MCCB'S & MPCB'S FOR MAINTENANCE SAFETY REASONS ON MOTORS / EQUIPMENT.
- MAINTENANCE TEAM TO UTILIZE LOTO FEATURE BEFORE INITIATING ANY REPAIR / MAINTENANCE ON ALL ELECTRICAL EQUIPMENT / PUMPS / MOTORS / FANS / BLOWERS ETC.



23a. Construction Typology: Block set of Schneider /R2K of ABB if called for in the BOQ specifically.
23b.

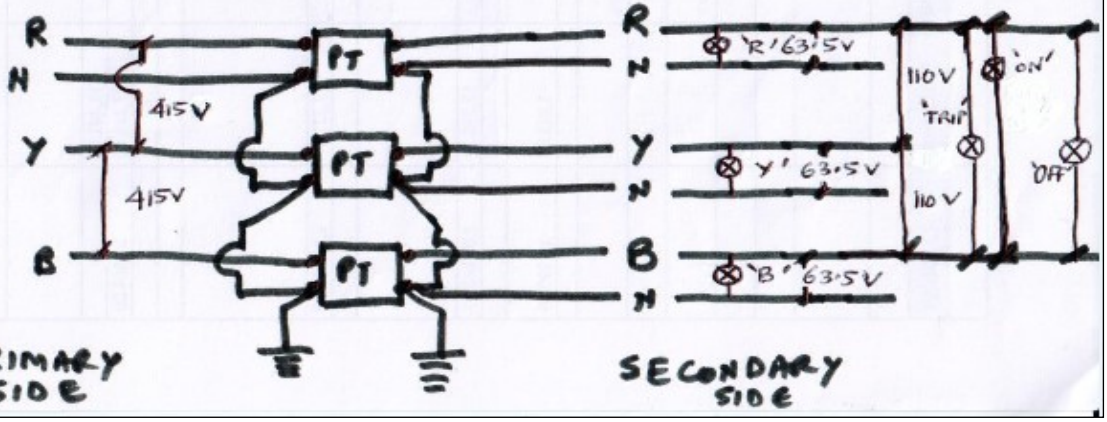
- PT's _ Metering PT's
- Control Transformers
- SMPS
- PLC's for Ventilation fans & Jet fans

(WIRING DETAILS)

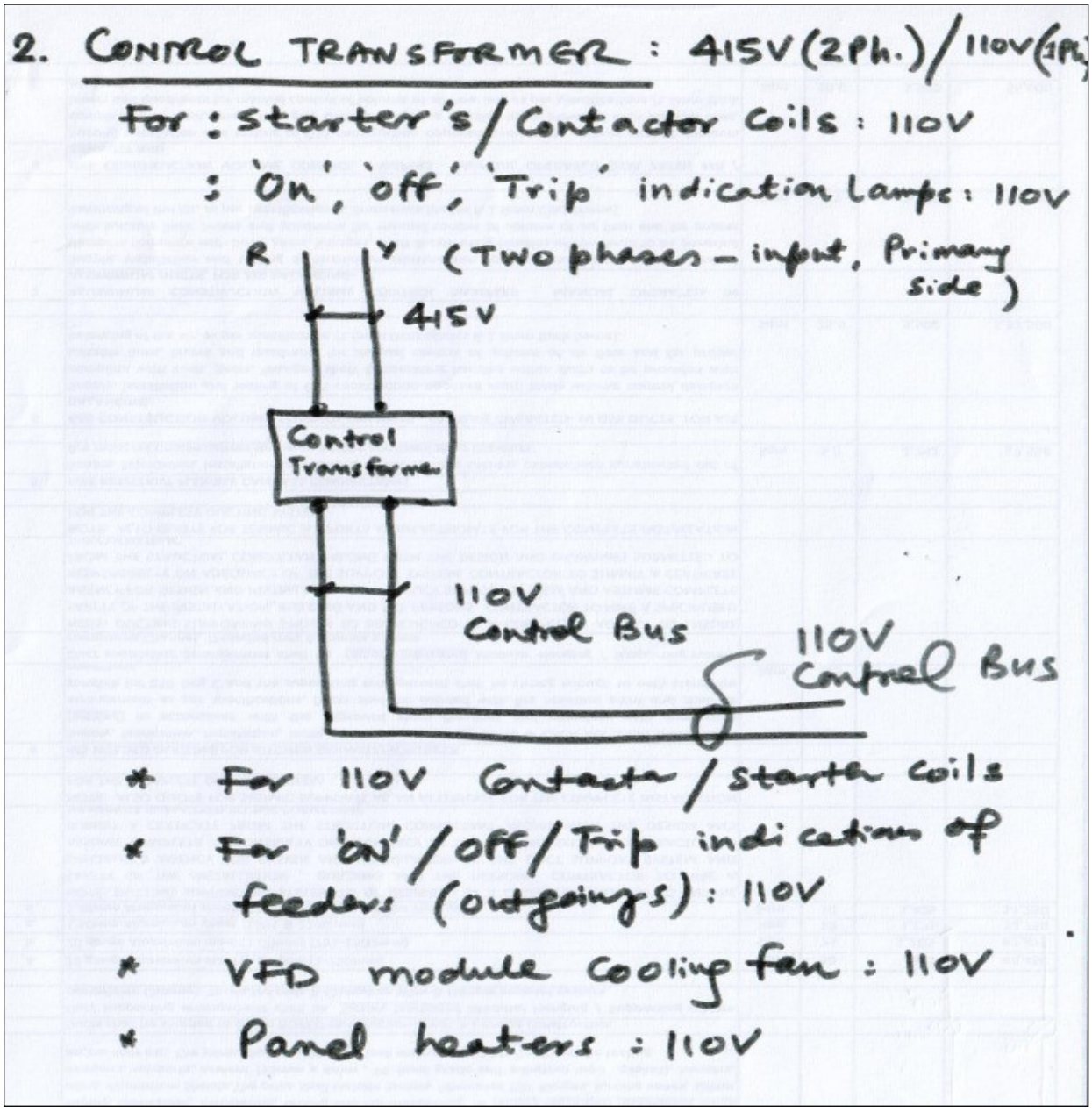
23b.1

1. PT @ Panel's incomer: Metering PT

- 415 V/√3 | 110V/√3
- 3 nos. Single Phase PT's.
- Input voltages : Primary side
  - Phase to Phase : 415 V
  - Phase to Neutral : 230V
- Output Voltages : Secondary side
  - Phase to Phase : 110V
  - Phase to Neutral : 63.5 V
- For :
  - R, Y, B phase indication Lamps : 63.5 V (1 phase)
  - MFM's : 3ph (110V)
  - On/Off/Trip indication Lamps : 110V (2 phase)



23b.2



23b.3. SMPS & CONTROL TRANSFORMER FOR 'CO' SENSORS POWER & PLC:

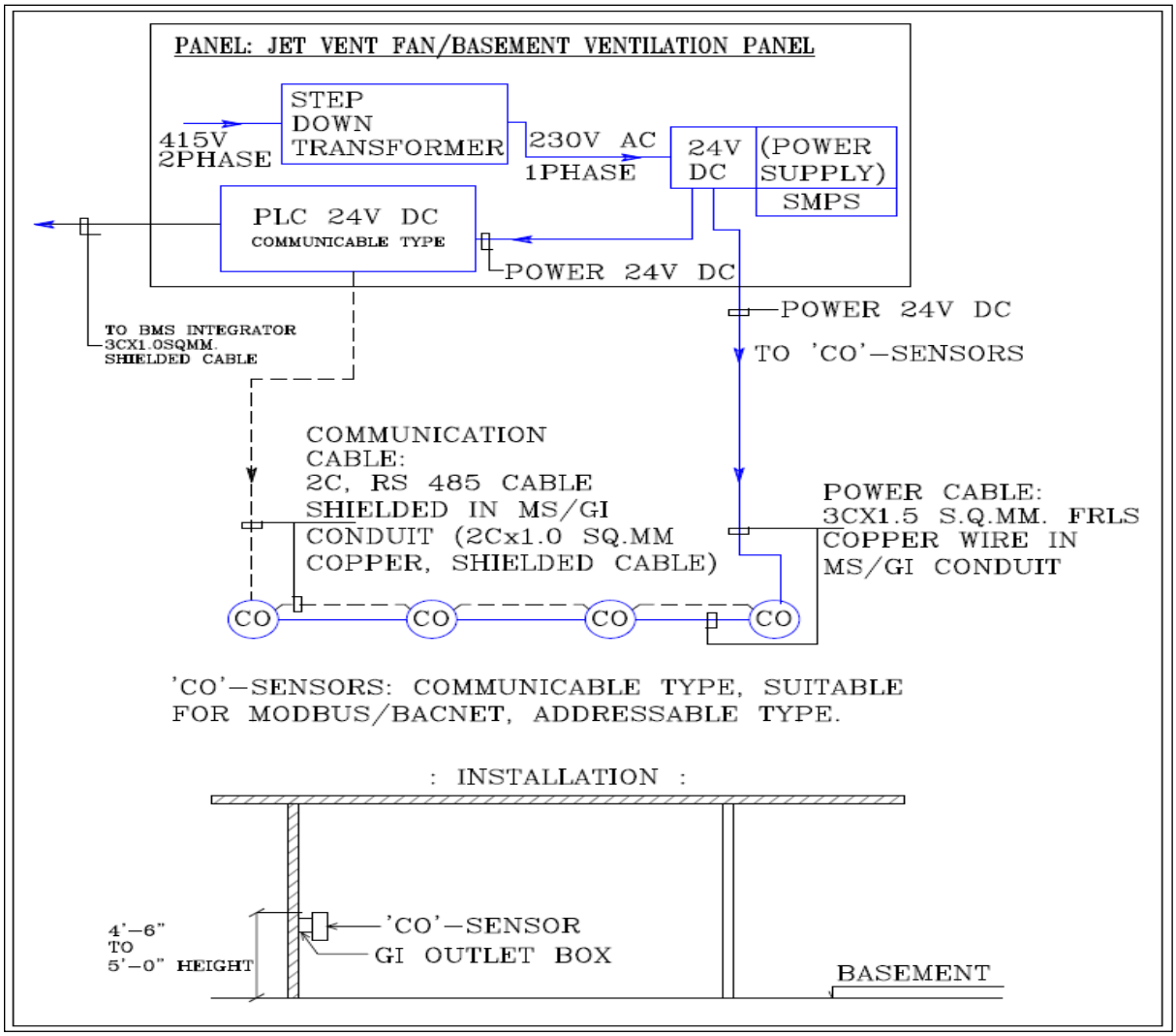
Step 1 (Control Transformer) : 415V (2 Phase) to 230V (1 Phase)

Step 2 (SMPS) : 230V (1 Phase) to 24V DC

24V DC Supply to:

- 'Co' Sensors
- 'PLC'

23b.4. PLC & CO SENSOR WIRING FOR BASEMENT VENTILATION PANELS:



SMPS & CONTROL TRANSFORMER FOR 'CO' SENSORS POWER & PLC:

Step 1 (Control Transformer) : 415V (2 Phase) to 230V (1 Phase)

Step 2 (SMPS) : 230V (1 Phase) to 24V DC

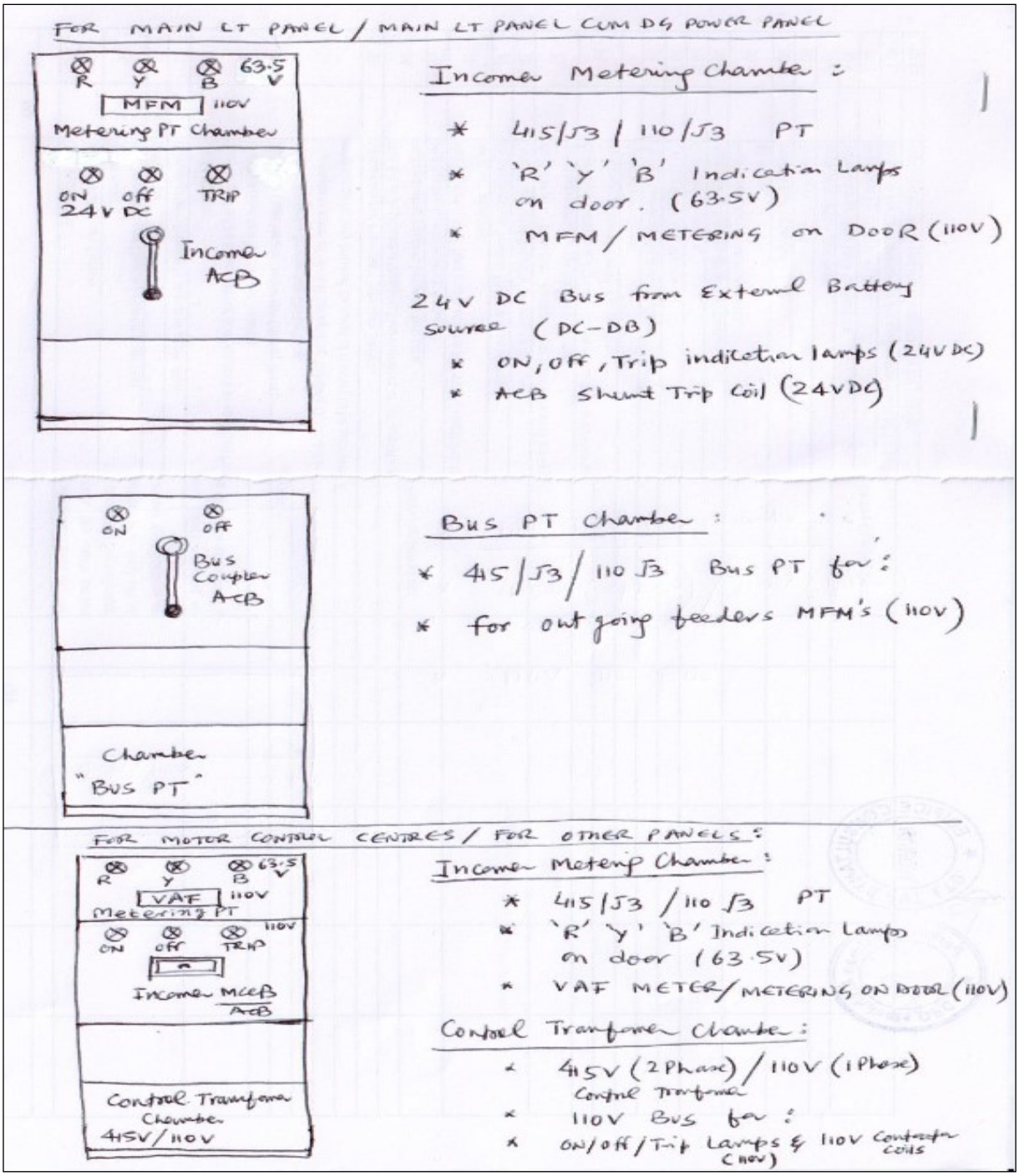
24V DC Supply to:

- 'Co' Sensors
- 'PLC'

PLC'S FOR JET FANS & BASEMENT VENTILATION FANS:

- Power Input: 24V DC
- Relay Outputs: 24 Nos.
- Analogue Outputs: 20 Nos.
- Modbus Input Ports (RS485) : 4 Nos.
- BMS Communication Port

23b.**5. FOR MAIN LT PANEL / MAIN LT PANEL CUM DG POWER PANEL:**



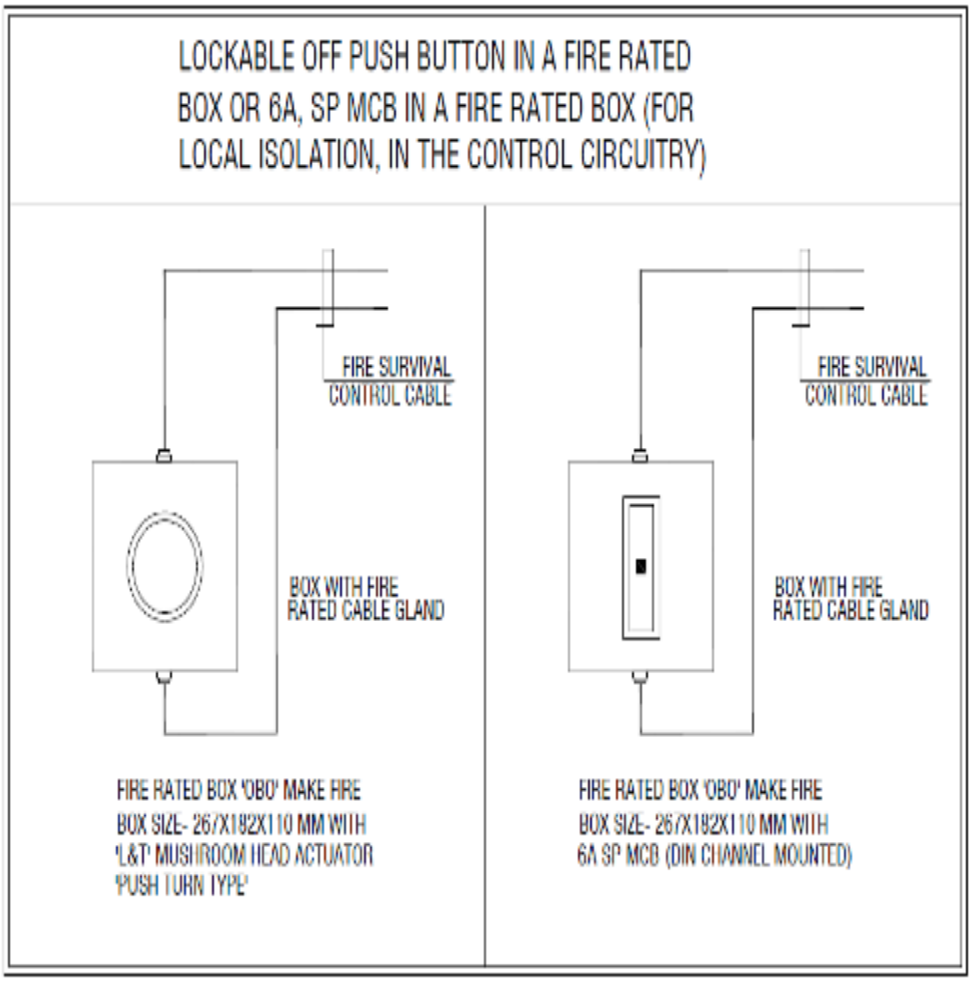
24 LOCAL ISOLATORS FOR MOTORS

Local Isolators

- Power Cables Isolators in power cables:
  - Cooling tower motor.
  - TFA motor.
  - HRW fresh air fan & exhaust air fan motors.
  - Staircase pressurization fan motor.
  - Lift lobby pressurization fan motor.
  - Lift well pressurization fan motor.
  - Toilet exhaust fan motor.
  - Pantry exhaust fan motor.

- Terrace located smoke venting fan motor for smoke & fresh air fans.
- STP exhaust fan motor.
- STP fresh air fan motor.

- Lockable off push buttons in control wiring for fans with fire rated cables (to avoid jointing in fire rated power cables):
  - Basement ventilation fan motors (fresh air & exhaust air).
  - Podium ventilation fan motors (fresh air & exhaust air).
  - Floor smoke venting fan motors (for fresh air & exhaust air).
  - MEP Rooms ventilation fan motors.



GALGOTIAS UNIVERSITY

SUBHEAD-T. VARIABLE REFRIGERANT VOLUME SYSTEM (VRV)

1. GENERAL

The air-conditioning system shall exhibit 'Capacity control' operating features providing very efficient energy and maximum comfort to the users. The VRV system shall be air-cooled, variable refrigerant system consisting of modular outdoor units and multiple indoor units, each heaving capability to cool independently and serving the different requirements of the room and users.

2. **SCOPE**

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

03 TYPE

Units shall be air cooled, variable refrigerant volume air conditioner consisting of one outdoor unit and multiple indoor units. Each indoor units having capability to cool or heat independently for the requirement of the specified area/ rooms.

It shall be possible to connect minimum 10 indoor units on one refrigerant circuit. The indoor units on any circuit can be of different type and also controlled individually. Following type of indoor units shall be connected to the system:

Ceiling mounted cassette type (Multi flow)
Ceiling mounted Ductable type
Wall mounted type

Compressor installed in outdoor unit shall be equipped with all inverter compressor.The system shall be capable of changing the rotating speed of inverter compressor by inverter controller to follow variations in cooling and heating load.

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

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

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

04 OUTDOOR UNIT

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

All outdoor units shall have minimum two scroll compressors and be able to operate even in case one of compressor is out of order.
In case of outdoor units above 16HP, the outdoor unit shall have at least 2 inverter compressor so that the operation in not disrupted with failure of any compressor.
It shall also be provided with duty cycling for multiple inverter compressor switching starting sequence of multiple outdoor units.

The outdoor unit shall be modular in design and should be allowed for side by side installation.

The unit shall be provided with its own microprocessor control panel.

The outdoor units shall have anti-corrosion paint.
The outdoor unit shall be fitted with low noise, aero spiral design fan with grill for spiral discharge airflow to reduce pressure loss and should be fitted with DC fan motor to better efficiency. The ductable unit shall be capable to deliver 40mm external static pressure to meet long duct connection requirement.

The condensing unit shall be designed to operate safely when connected to multiple fan coil units.

4. COMPRESSOR

The compressor shall be highly efficient scroll type and capable of inverter control. It shall change the speed in accordance to the variation in cooling or heating load requirement:

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 stock. Forced lubrication shall also be employed.

Oil heater shall be provided in the compressor casing.

5. HEAT EXCHANGE

The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to from a cross fin coal.

The aluminum fins shall be covered with anti-corrosion resin film.

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

6. REFRIGERANT CIRCUIT

The refrigerant circuit shall include liquid (refrigerant – R-22/R-407c/ R-134a) & gas shut-off valves and a solenoid valves at condenser end.

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

7. OIL RECOVERY SYSTEM

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

Indoor Unit

This section deals with supply, installation, testing, commissioning of various type of indoor units confirming to general specification and suitable for the duty selected. The type, capacity and size of indoor units shall be as specified in detailed Schedule of Quantities.

8. GENERAL FOR INDOOR UNITS:

Indoor units shall be either ceiling mounted cassette type, or ceiling mounted ductable type or wall mounted type as specified in Schedule of Quantities. These units shall have electronic control valve to control refrigerant flow rate respond to lead variations of the rooms.

The address of the indoor unit shall be set automatically in case of individual and group control.

In case of centralized control, it shall be set be liquid crystal remote controller.

The fan shall be dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balanced to ensure low noise and vibration free operation of the system. The fan shall be direct driven type, mounted directly on motor shaft having supported from housing.

The cooling coil shall be made out of seamless copper tubes and have continuous aluminium fins. The fins shall be spaced be collars forming and integral part. The tubes shall be staggered in the direction of airflow. The tubes shall be hydraulically/ mechanically expanded for minimum thermal contact resistance with fans. Each coil shall be factory tested at 21kg/sqm air pressure under water.

Unit shall have cleanable type synthetic non woven type filter fixed to an integrally moulded plastic frame. The filter shall be slide away type and neatly inserted.

Each indoor unit shall have computerized PID control for maintaining design room temperature. Each unit shall be provided with microprocessor thermostat for cooling and heating.

Each unit shall be with wired LCD type remote controller. The remote controller shall memorize the through its touch screen, icon display and color LCD display.

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

Starting/ stopping of Air conditioners as a zone or group or individual unit.

Temperature settling for each indoor unit or zone.
Switching between temperature control modes, switching of fan speed and direction of airflow, enabling/ disabling of individual remote controller operation.

Monitoring of operation status such as operation mode & temperature setting of individual indoor units, maintenance information, trouble shooting information.

Display of air conditioner operation history.

Daily management automation through yearly schedule function with possibility of various schedules.
The controller shall have wide screen user friendly color LCD display and can be wired by a non polar 2 wire transmission cable to a distance of 1 km. away fro indoor unit.

9. HEAT RECLAIM VENTILATION UNIT:
In order to achieve the purpose of better indoor air quality, the Heat Reclaim ventilation (HRV) unit must exchange the heat between supplied fresh air and exhausted air in order to bring the outside air closer to indoor temperature and humidity conditions. Thus it must recover the thermal energy of exhaust air and reuse it for supplied fresh air. This must lead to ventilation without increasing the load and thus saving in running cost.

It shall be possible to interlock this HRV system with operation of VRV system to simplify installation and improving the efficiency of air-conditioning.

The casing of the HRV unit shall be made of galvanized steel plate, insulation with self extinguishable polyurethance foam. The must have air filters of multo directional fibrous fleeces type.
The heat exchange element must be designed without any moving parts for higher durability and reliability, it should have high permeability high efficiency specially processed paper which is flame retardant and fungi proof to keep air clean.

The unit must be provided with built-in multidirectional fibrous filter.

The unit must have optimized design of fan and air flow passage to make it compact and supply air & exhaust air passage must be arranged in such pattern so as to prevent mixing of supply (fresh) and exhaust air.

The unit must be suitable for single phase supply and have their control panel.

Latest malfunction code for easy maintenance. The controller shall have self-diagnostic feature for easy and quick maintenance and service. The controller shall be able to change fan speed and angle of swing flat individually as per requirement.

10. CEILING MOUNTED CASSETTE TYPE UNIT (MULTI FLOW TYPE):
The unit shall be ceiling mounted type. The unit shall include synthetic non-woven type filter, fan section and DX-coil section. The housing of the unit shall be powder coated galvanized steel. The body shall be light in weight and shall be able to suspend from four corners.

Unit shall have an external attractive panel for supply and return air. Unit shall have one-way/ two-way/ four-way supply air grillers on sides and return air grille in centre.

Each unit shall have high lift drain pump, fresh air intake provision, Low gas detection system and sound level shall be less than 38 db at 1.5 mtr. Distance.

All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view. It should have provision of connecting branch ducts.

11. CEILING MOUNTED DUCTABLE TYPE UNIT:
Unit shall be suitable for ceiling mounted type. The unit shall include pre filter, fan sections & DX coil section. The housing of unit shall be light weight powder coated galvanized steel. The unit shall have high static fan for Ductable arrangement.

12. CEILING SUSPENDED TYPE:
Unit shall be suitable for ceiling suspended arrangement below false ceiling. The unit include pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

13. HIGH WALL MOUNTED UNITS:
The units shall be wall-mounted type. The unit includes pre filter, fan section & DX coil section. The housing for unit shall be light weight powder coated galvanized steel.

Unit shall have an attractive external casing for supply and return air.

14. FLOOR STANDING TYPE:
Unit shall be suitable for floor standing arrangement. The unit includes pre filter, fan section & DX coil section. The housing of unit shall be light weight powder coated galvanized steel.

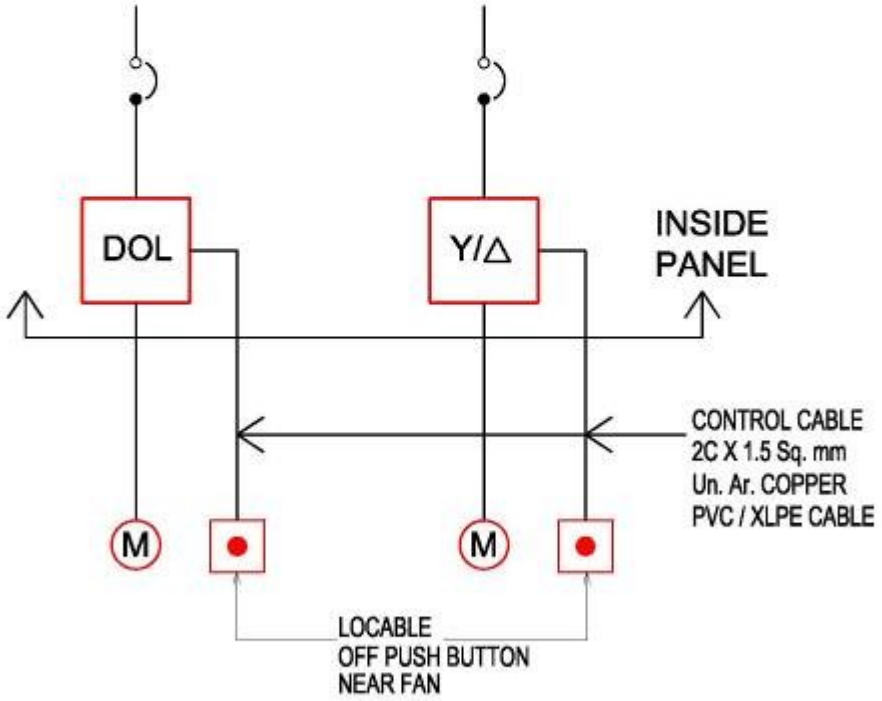
Centralized Type Remote (Touch Screen Type) Controller

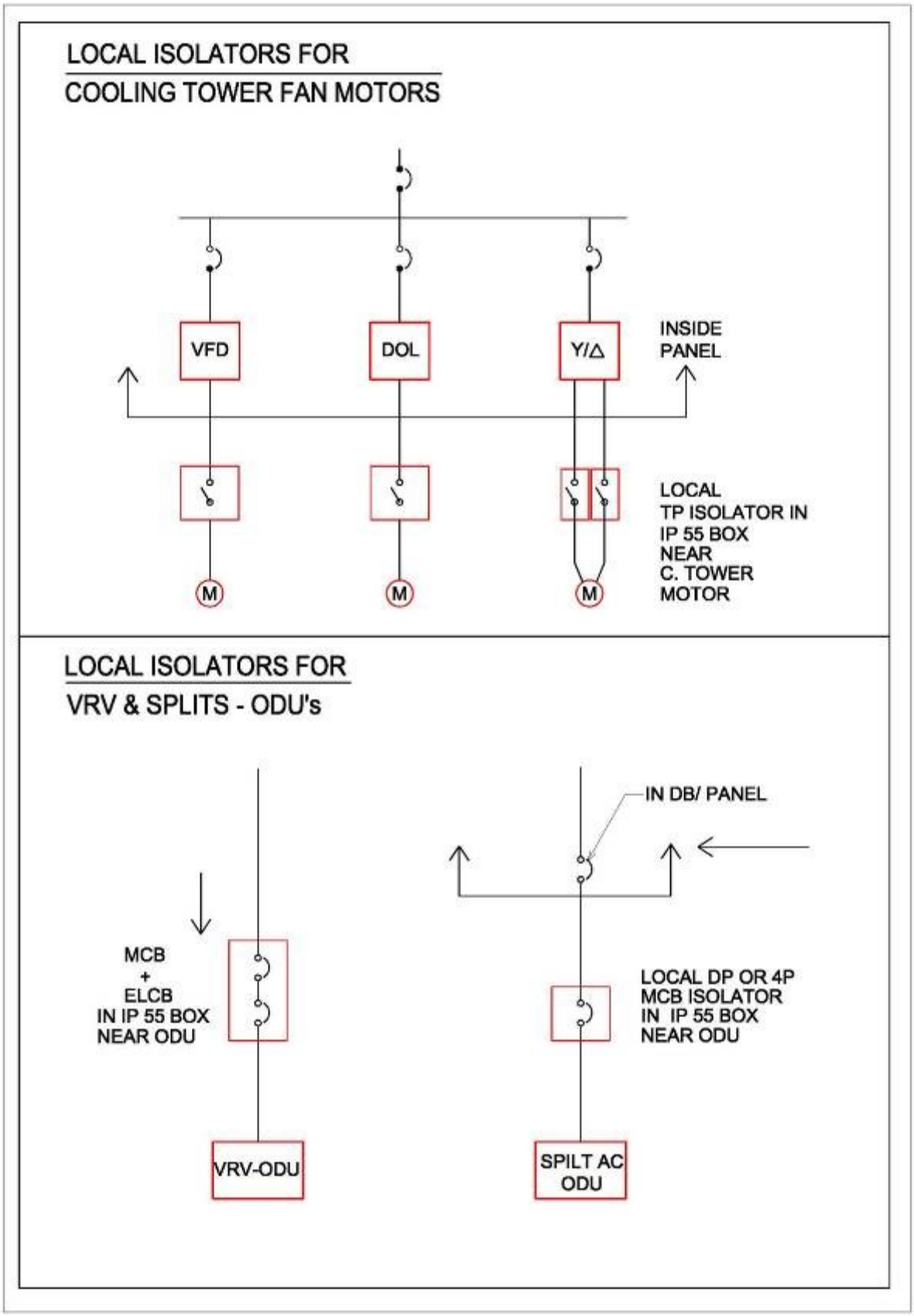
A multifunctional compact centralized controller shall be provided with the system.

The Graphic Controller must act as an advanced air conditioning management system to give complete control of VRV air conditioning equipment, it shall be have ease of use for the user.

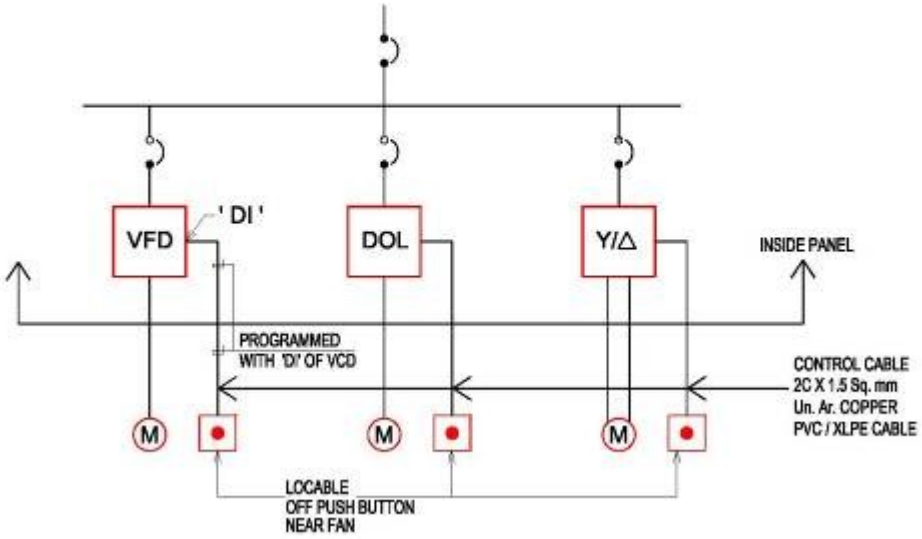
LOCAL ISOLATORS FOR

C.S. VENTILATION UNIT's (FRESH AIR / EXHAUST AIR)
FOR : LT PANEL
DG ROOM
SUB STATION AREA / TRANSFORMER ROOM
PUMP ROOM
STP ROOM
AC PLANT ROOM

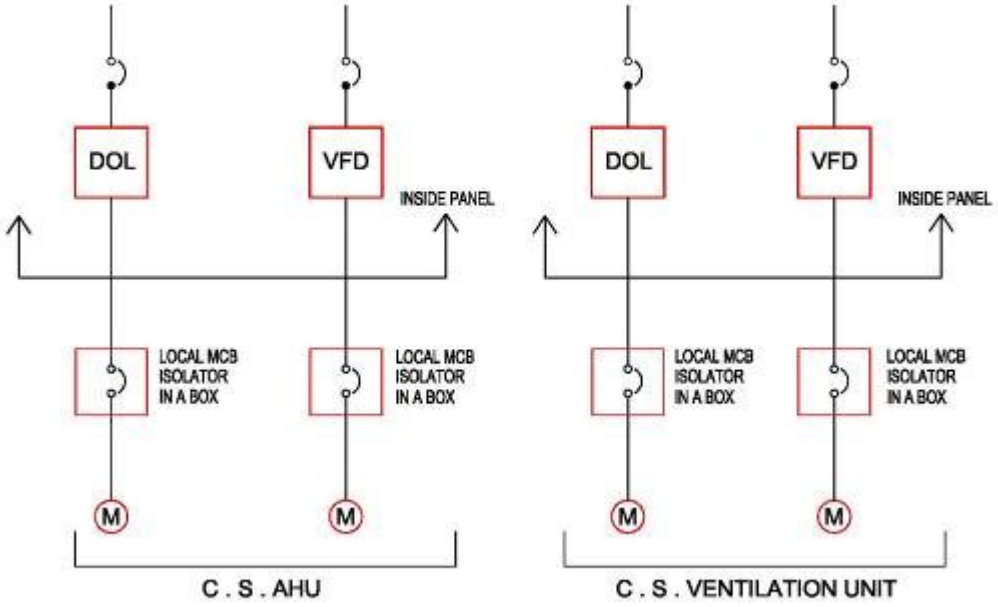


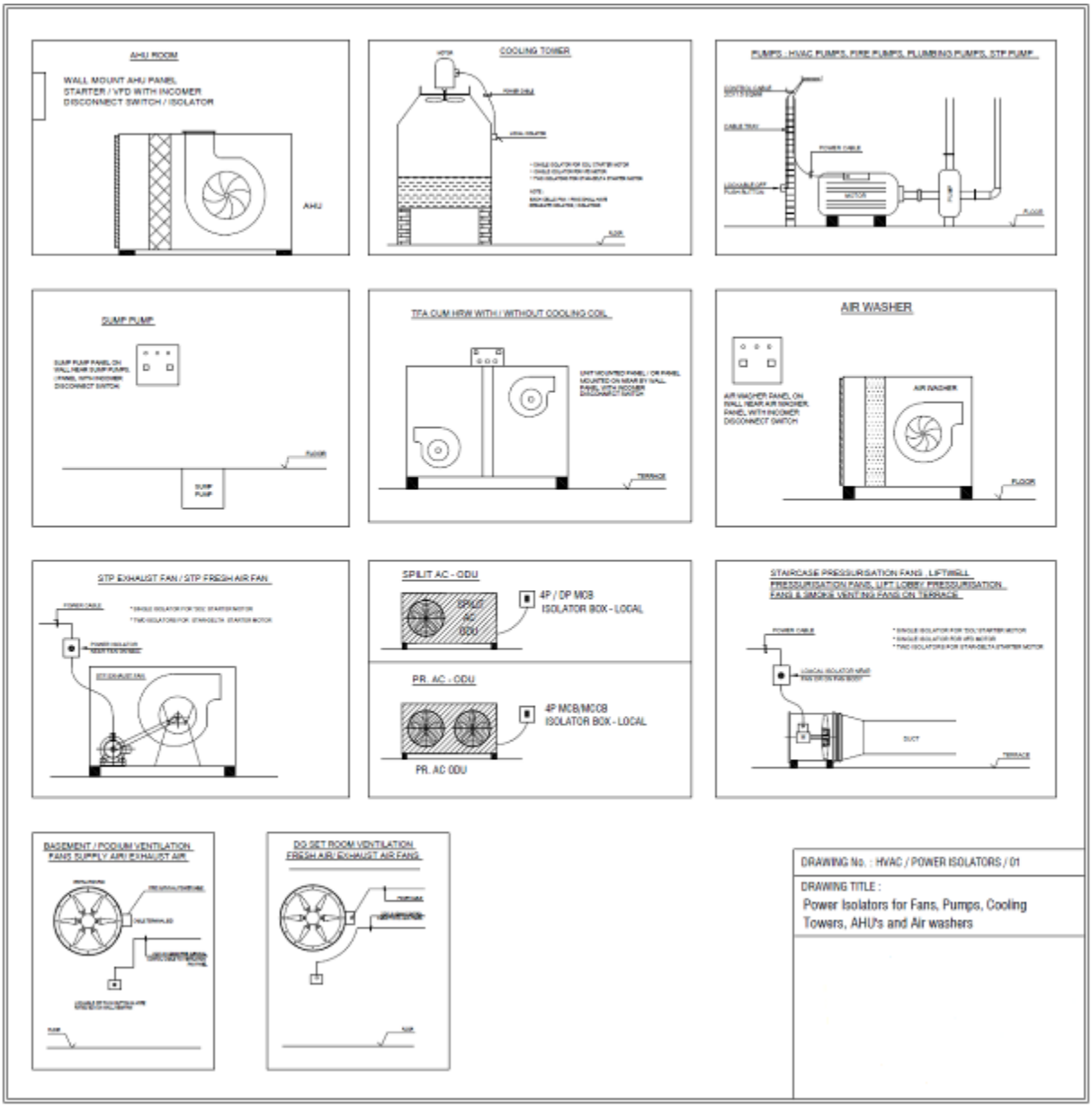

LOCAL ISOLATORS FOR
COOLING TOWER FAN MOTORS
VFD
DOL
Y/Δ
INSIDE PANEL
LOCAL TP ISOLATOR IN IP 55 BOX NEAR C. TOWER MOTOR
M
M
M
LOCAL ISOLATORS FOR
VRV & SPLITS - ODU's
IN DB/ PANEL
MCB + ELCB IN IP 55 BOX NEAR ODU
LOCAL DP OR 4P MCB ISOLATOR IN IP 55 BOX NEAR ODU
VRV-ODU
SPILT AC ODU

LOCAL ISOLATORS FOR
BASEMENT VENTILATION FANS / SMOKE VENTING FANS / CAR PARK VENTILATION / PODIUM VENTILATION / MCCB (WHERE FIRE RATED POWER CABLE ARE USED)



LOCAL ISOLATORS FOR
C.S.AHU 's / C.S. VENTILATION UNITS / TOILET EXHAUST VENTILATION UNIT PANTRY EXHAUST VENTILATION UNIT




AHU ROOM
WALL MOUNT AHU PANEL
STARTER / VFD WITH INCOMER
DISCONNECT SWITCH / ISOLATOR
AHU
COOLING TOWER
FLOOR
PUMPS : HVAC PUMPS, FIRE PUMPS, PLUMBING PUMPS, STP PUMP
CABLE TRAY
POWER CABLE
MOTOR
FLOOR
SUMP PUMP
SUMP PUMP PANEL ON WALL NEAR SUMP PUMP(S) WITH INCOMER DISCONNECT SWITCH
FLOOR
SUMP PUMP
TFA CUM HRW WITH / WITHOUT COOLING COIL
UNIT MOUNTED PANEL / DP PANEL MOUNTED ON NEAR BY WALL PANEL WITH INCOMER DISCONNECT SWITCH
TERRACE
AIR WASHER
AIR WASHER PANEL ON WALL NEAR AIR WASHER PANEL WITH INCOMER DISCONNECT SWITCH
AIR WASHER
FLOOR
STP EXHAUST FAN / STP FRESH AIR FAN
POWER CABLE
STP EXHAUST FAN
SPLIT AC - ODU
SPLIT AC ODU
4P / DP MCB ISOLATOR BOX - LOCAL
PR. AC - ODU
PR. AC ODU
4P MCB/MCCB ISOLATOR BOX - LOCAL
STAIRCASE PRESSURISATION FANS, LIFTWELL PRESSURISATION FANS, LIFT LOBBY PRESSURISATION FANS & SMOKE VENT/NX FANS ON TERRACE
POWER CABLE
DUCT
TERRACE
BASEMENT / PODIUM VENTILATION FANS SUPPLY AIR/ EXHAUST AIR
FLOOR
DG SET ROOM VENTILATION FRESH AIR/ EXHAUST AIR FANS
FLOOR
DRAWING No. : HVAC / POWER ISOLATORS / 01
DRAWING TITLE :
Power Isolators for Fans, Pumps, Cooling Towers, AHUs and Air washers

SUBHEAD-U. AIR COOLED SPLIT AIR CONDITIONING UNITS

1 Scope:

The scope of this section comprises of supply, erection, testing and commissioning of air-cooled split units conforming to these specifications and in accordance with the requirements of drawings and Schedule of Quantities.

2 Type:

The split units shall consist of hermetic/semi-hermetic sealed, reciprocating/scroll compressor, motor, air-cooled condenser, integral refrigerant piping and wiring, all mounted on a steel frame.

Indoor unit to be installed within building shall be housed insulated cabinet consisting of cooling coil, blower with motor, filter & insulated drain pan. The indoor units shall be hi-wall / furred-in / verticool slim line / cassette / ductable as called for in the BOQ.

3 Capacity:

The refrigeration capacity of split units shall be as shown on drawings and in Schedule of Quantities.

4 Compressor and Motor:

Compressor shall be hermetic/semi-hermetic, reciprocating/scroll, serviceable type and shall have dual pressure stat, and an operating oil charge. The motor shall be suction gas cooled and shall be sealed against dirt and moisture. The motor shall be suitable for 415□± 10% volts or 230□± 10% volts, 50 Hz, ac supply.

5 Refrigerant piping and controls:

Refrigerant piping and fittings interconnecting compressor, condenser shall be all copper and valves shall be brass/gunmetal construction.

6 Casing:

The indoor & outdoor units shall be sectionalized / cabinet construction. Indoor units shall be consisting of fan section, coil section, filter section, and drain pan. Outdoor unit shall consist of condenser coil, fan & compressor. In case of package units the compressor shall be mounted within the indoor units and in case of split unit the compressor shall be mounted within the outdoor units. Each section shall be constructed of thick sheet steel all welded/bolted constructed, adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Base panel shall be constructed / fabricated steel structure provided with an under frame suitably braced. Each unit shall include one place drain pan constructed of 20 gauge galvanized sheet steel plate. Drain pan shall extend under coil and fan sections with drain connections. Removable panels in fan and coils sections shall provide access to all internal parts.

Panels shall be internally lined with 2.5 cms. thick fibreglass as per section “Insulation” for the thermal insulation and acoustic lining.

7 Fan Motor and Drive:

Fan motor shall be suitable for 415□± 10% volts or 230□± 10% volts, 50 Hz, AC supply, single phase, motors shall be provided with permanent capacitor. Motors shall be specially designed for quiet operation and motor speed shall not exceed 1440 rpm.

8 Blower:

Blower wheels and housing shall be fabricated from heavy gauge steel. Blower wheels shall be of double-width, double inlet forward-curved, multi-blade type enclosed in housing and mounted on a common shaft. Blower housings shall be made of die-formed steel sheets with stream-lined inlets to ensure smooth air flow into the fans, blower shaft bearings shall be oil/grease lubricated. All rotating parts shall be dynamically balanced individually, and the complete assembly shall be statically and dynamically balanced. Blower speed shall not exceed 1000 rpm and maximum outlet velocity shall be 550 meters per minute.

9 Cooling Coil:

Cooling coils shall be of fin and tube type having 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 air velocity across each coil

shall not exceed 100 meters per minute. The coil shall be pitched in the unit casing for proper drainage. Each coil shall be factory-tested at 21 Kg per sq.cm air pressure under water. Tube shall be mechanically/ hydraulically expanded for minimum thermal contact resistance with fins. The number of fins per cm. shall be 4 to 5.

10 Vibration Isolators:

The indoor and outdoor units shall be provided with ribbed rubber pad vibration isolators.

11 Painting:

Split units shall be factory finished with durable alkyd spray enamel. Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, then coated with enamel paint to match the finish over the adjoining shop-painted surface.

12 Performance Rating:

The unit shall be selected for the lowest operating noise level. Capacity ratings and power consumption with operating points clearly indicated shall be submitted with the tenders and verified at the time of testing and commissioning of the installation.

REFRIGERANT PIPING

Material composition should be conforming to C-1220 (JIS-H-3300) or C-12200 (ASTM). It should have a minimum Copper content of 99.9% and Phosphorus content between 0.015% & 0.04%.It should have low residue (below 0.038 gm/Sqmt.). The material should also be as per the RoHS norms specified by EU; that is, Mercury, Chromium & Lead contents below 1000PPM and Cadmium content below 100 ppm.
Physical properties of the material should conform to JIS - H-3300 or ASTM-B-68 & B-75, should be tested for Tensile / Elongation / Hardness / Grain size tests as per ASTM-B-280.

All refrigerant piping for the air-conditioning system shall be constructed from soft seamless upto 19.1mm and hard drawn copper refrigerant pipes for above 19.1mm with copper fittings & silver-soldered joints. The refrigerant piping arrangements shall be in accordance with good practice within the air-conditioning industry and are to include charging connections, suction line insulation & all other items normally forming part of proper refrigerant circuits.
All joints in copper piping shall be sweat joints using low temperature brazing and or silver solder. Before jointing any copper pipe or fittings, its interiors shall be thoroughly cleaned by passing a clean cloth via wire or cable through its entire length. The piping shall be continuously kept clean of dirt etc. while constructing the joints. Subsequently, it shall be thoroughly blown out using nitrogen.
After the refrigerant piping installation has been completed, the refrigerant piping shall be pressure tested using nitrogen at pressure of 20KG / Sqcm. & 10KG / Sqcm. (low Side). Pressure shall be maintained in the system for 24hrs. The system shall then be evacuated to minimum vacuum of 700mm Hg & held for 24hrs.
The air-conditioning system supplier shall design sizes & erect proper interconnections of the complete refrigerant circuits.
The thickness of copper piping shall not be less than 18G for pipes upto 19.1mm & 16G for bigger sizes.
The suction line pipe size & the liquid line pipe size shall be selected according to the manufacturers specified outside diameter. All refrigerant pipes shall be properly supported & anchored to the building structure using steel hangers, anchors, brackets & supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size & number to support the load imposed thereon.
To protect Nitrile rubber insulation of outdoor installed copper piping from degradation due to ultra violet rays and atmospheric condition, it shall be covered with polyshield coating / al. cladding 24 swg of at least two coats of resin and hardener (poly bond make or equivalent). Fibre glass type shall be helically wound with adequate overlap & coated with two coats of resin with hardener to give smooth & plain finish.
Entire liquid and suction refrigerant pipe lines including all fittings, valves and strainer bodies etc. shall be insulated with 19mm / 13mm thick electrometric nitrile rubber as specified in BOQ.

Tube Material Specification:

De-oxidized High Phosphorized copper (DHP Grade) raw material with chemical composition of:
Copper = 99.9%; Phosphorus = 0.015 to 0.040%.

1. RoHS compliant.

2. 360 Deg. concentric wall thickness along the entire length of the tubes.
3. Half hard drawn copper tubes should conform to ASTM B75/ ASTM 280 (C12200)/ JIS H: 3300 (C1220)/ BS2871 PART-3 (C106).
   Use half hard temper type for tube sizes above 19.1mm.
4. Soft copper tubes, bright annealed (mirror finish) should conform to ASTM B68/JIS H: 3300.
5. Super clean quality with low residual content below the permissible levels 0.038gms / m2 for compatibility with use of CFC-free refrigerant.
6. 100% Eddy current tested tubes are to be used.
7. Proper packaging, storage & traceability of the tubes.

Various sizes PVC insulated copper conductor wiring cables

PVC insulated multi stranded sheathed copper conductor wiring cable for working voltage upto & including 1100 Volts. ISI marked conforming to IS 694/1990 (Latest Version).

Wiring of installation shall be in conformity with IS 732/1989 (Latest Version), IS 4648/1968 (Latest Version).

Rigid PVC conduit pipe

Laying conduit shall be in conformity with IS: 732 / 1989 (Latest Version), IS 4648 / 1968 (Latest Version). Fitting for rigid non-metallic conduit shall conform to IS 3419 / 1989 (Latest Version) and accessories shall conform to relevant IS.

SUBHEAD-V. PRECISION AIR-CONDITIONING (PAC)

1. Precision Air-conditioning Units

The room air-conditioning system shall be designed specifically for with high sensible heat ratio, such as Telecommunication and Computer rooms.

Each unit shall be capable of providing sensible cooling capacities at rated ambient temperatures with adequate airflow.

The system shall be High Technology Scroll compressor, Evaporator, Condenser and electronic expansion valve all of which shall be contained within the cabinet of the unit.

2. Cabinet Construction

The frame and panels shall be constructed of heavy gauge Zinc-anneal corrosion resistant sheet steel. The fan section shall be insulated with minimum 25 mm thick fire rated insulation. The cabinet shall be powder coated and have a textured finish. The Indoor cabinet shall be with Double Skin Side Panels & front & back panels shall be with 25mm thick accoustic mineral wool insulation.

3. Evaporator Coil

The evaporator coil shall be constructed of copper tubes and slit aluminium fins, with G.I. frame and drip tray fabricated out of stainless steel. The cooling coil shall be a minimum of 4 row deep. The distance between the fins shall not be less than 1.8 mm and face velocity shall be less than 2.3 mts./sec. Aluminium fins have hydrophilic treatment on the surface to reduce water leakage. Evaporator surface must be designed to provide a very high level of sensible cooling capacity, i.e. Sensible Heat Ratio (SHR) shall be > 0.9 when relative humidity is 50%. The coil should have a SS drip tray to collect the condensed water. The unit shall be floor mounted shall be designed / suitable for 24/7 operation in all respects

4. Compressor

The compressor shall be of high efficiency, High Technology SCROLL design. Compressor shall have inbuilt overloads, and shall be mounted on anti vibration mountings. Refrigerant is R-407C.

Compressor refrigerant circuit shall have vibration absorbers at suction & discharge lines, Compressor EER should not be less than 11.1 Btuh / Watt (COP not less than 3.25 at ARI conditions)

5. Refrigeration circuit

The refrigeration circuit shall be direct expansion type and incorporate high efficiency, High Technology scroll compressor. The system shall include a manual reset HP and an auto reset LP switch, filter drier and charging port. An electronic expansion valve, sight glass and filter drier shall be provided for each circuit.

6. Fans & Motor: Electronically Commutated Drives

Unit must be provided with composite blade design plug fans, each running with DC drive electronically communicated motors, the fans should be aligned and balanced statically and dynamically. The fan speed must be controlled based on the room return air Temperatures and also must have automatic speed control without manual intervention. The fans can be one /two/ three no's as per the manufacturer's standard. Fan shall be of composite blade design (a mixture of plastic & aluminium)

7. Service Area

The unit shall be serviceable with a maximum service space of 870mm in front of the unit.

8. Air Filtration

Filtration shall be provided by dry media disposable filters capable of filtering air to 95% (@5 micron) efficiency and shall be replaceable from the top of the unit. Filter made out of combustible material shall not be used.

9. Air-cooled condensers

The standard condensers shall be factory matched to provide an operating range from 0^0C to 45^0C. Optional low ambient refrigeration controls (LARC) shall also be available to extend the operating range down to 0^0C.

The condenser frame shall be constructed from heavy duty galvanized steel and incorporate copper tube and aluminium fin coil.

The coil shall be a minimum of 4 rows deep, with a minimum fin spacing of 2.0 mm and maximum face velocity of 3.6 m/s.

The condenser fan(s) shall be directly driven by 1250 rpm electric motor(s). 6 pole, 900 rpm fan motors shall be used for low noise condensers. Condenser fan shall be with fan speed controller.

Condensation control

The condensation control must detect the gas pressure at the compressor discharge that is on board for the CRAC unit: this is both to measure the actual delta P of the compressor and to allow a simultaneous calibration of the evaporator-condenser system. Condensation control has to be via modulation of voltage tension of condenser fans.

10. Heater & Humidifier

The evaporator unit shall also have suitable capacity / rated heater & humidifier unit.

11. Controls

The standard controls shall be of microprocessor based programmable PID logic controller. The controller shall have a LCD display screen, which shall be visible from the front of the unit without removing any covers/external panels.

The controls shall have separate indications for

a. Various modes of operation (cooling, heating)
b. Alarm conditions (temperature high, wet floor and loss of air flow)
c. Graphical displays of set temperature and achieved temperature.
d. Date, time and unit identification display
e. Back up battery charge status display on the controller screen
f. Visual system alarm indication (along with mutable audio alarm as well)
g. 48 hrs temperature graph display menu
h. Programmable services interval indication display

The system shall have a menu driven interface with supporting help screens and shall use multi-protocol data communications. Access to the controller settings shall be protected with passwords to prevent against unauthorized access.

The unit shall be capable of communicating through an RS-232 communication support to link upto 99 units for monitoring and control purposes. The controller should also incorporate 2 additional spare alarm inputs for customer interface (e.g. Unauthorized entry alarm, building fire alarm etc.) manual override switches & selectable alarms. Local & remote alarms will be triggered in case of any alarm conditions being reached.

The unit shall also incorporate the following protections:

- Single phasing preventors.
- Reverse phasing
- Phase imbalancing
- Phase failure
- Overload tripping (MPCB) of all components

Notes:

- The unit shall be equipped with intelligent controller to control the operation & speed of compressor, EC Fan & Condenser fan.
- It shall also ensure cyclic operation of various Pr. AC units inside the room / space.
- Necessary sensors shall also be required along with the unit.
- The unit shall have water leak detection sensing tape with alarm initiation system, on detection of water leakage under the machine in the vicinity.
- The unit shall have a feature to trip off automatically in the event of receiving a fire signal from the fire detection system. The necessary cabling between the fire relay control module with in the space/room and the unit's controller shall be considered in the scope of work and supply.

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CHILLER SYSTEM

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TECHNICAL SPECIFICATIONS

SECTION-A. WATER-COOLED CENTRIFUGAL LIQUID CHILLING PACKAGE WITH VFD

1.1 SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at supplier's works, delivery at site, handling at site, installation, testing, commissioning and carrying out performance test at site of Water-Cooled Centrifugal Liquid Chilling Packages.

1.2 CODES AND STANDARDS

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

ASHRAE 15	Safety Code for Mechanical Refrigeration
ASHRAE 23	Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units
ASHRAE 30	Methods of Testing Liquid Chilling Packages
ASME SEC. VIII DIV. 1 / GB/PED	Boiler and Pressure Vessel Code
ANSI B 31.5	Code for Refrigeration Piping
AHRI 550 / 590	Standard for Water Chilling Packages
AHRI 575	Standard for Method of Measuring Machinery Sound within an Equipment Space
ISO 1940	Mechanical Vibration - Balance Quality Requirements of Rigid Rotors
ISO 10816-1	Mechanical Vibration - Evaluation of Machine Vibration by Measurements on Non-Rotating Parts. General Guidelines
TEMA	Standards of the Tubular Exchanger SUB-CONTRACTORs Association

1.3 GENERAL REQUIREMENTS

Each Chilling package shall be complete assembly of all components viz. electric motor driven semi-hermetic or open Centrifugal compressor, insulated cooler, condenser, refrigerant piping, oil cooler, protective devices, microprocessor control panel, unit mounted starter cum local electrical panel, etc. mounted on a common structural frame. The Chiller package shall be suitable for indoor installation.

Performance will be certified in accordance with AHRI Standard.

All rotating parts shall be statically and dynamically balanced.

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

Requirement of refrigerant, oil and other consumables shall be provided by the contractor till the plant is taken over by the EMPLOYER.
The chilling package shall be despatched to site in fully assembled and factory tested condition

with the full refrigerant and oil charge.

The entire water-cooled Centrifugal liquid Chilling package shall be imported, as a fully assembled and factory tested unit

The Refrigerant shall be Eco-friendly R-134a , as per Ashrae A1 safety classification.

The minimum Full load COP for water cooled chiller should be 6.3 as per the test standards of AHRI 550/590 or as specified in the BOQ.

1.4 CENTRIFUGAL COMPRESSOR

The compressor shall be single/double stage, open / semi-hermetic type, using refrigerant R-134a. The shrouded impeller shaft shall be either direct driven or connected to the speed increasing gear. It shall be self-aligned and balanced and shall be assembled in the compressor casing. The driven end of the gear shaft shall be connected with the motor through a flexible coupling. The shrouded impeller shall be cast from alloy steel / aluminium alloy. This shall be statically and dynamically balanced to ensure vibration free operation.
Sound as per AHRI 575, shall be less than 85 dBa on all loads from 100%-15% (Manufacturer must furnish AHRI certified Computerised sheet to show this compliance before technical clearance.)

1.5 MOTOR

Open /semi-hermetic system shall be suitable for 415 +/- 10% volts, 3 phase, 50 cycles AC supply. Motors shall be screen protected drip proof / TERC squirrel-cage induction type, designed and guaranteed for continuous operation at name plate rating.

The motor shall be provided with a combination of ball and roller bearing, and shall be fitted at the free end with ample capacity to deal with any axial thrust. Limit type lubricators shall be provided to enable the bearings to be correctly greased.

The tenderer should also indicate IKW/TR for part load conditions of 30%, 40%, 50%, 60%, 70%, 80% and 90% at both AHRI relief and constant condenser water entering condition.

1.6 VFD

Variable speed drive shall be preferably unit mounted. Free standing VFD shall also be accepted if sourced and tested at manufactures works before dispatch. In case free standing VFD is offered, Cost of power cable , control cable, cable tray, termination boxes , VFD stand and other accessories must be included in above price. Cable length must be calculated assuming 10 M horizontal distance between motor and VFD. VFD unit mounted/free standing shall be suitable

for NEMA 1 enclosure with power & control wiring between drive & controller including power to compressor oil pump. Incoming power supply shall be single point termination.
Central control panel must display VSD readouts as well and provide Bacnet out put for software integration also.

VFD shall be refrigerant/liquid cooled, as per manufacturer standard.

VFD shall employ an advanced sine wave approximation & voltage vector control to allow operation at rated motor shaft output speed with no deration. This voltage vector control shall minimize harmonics to motor in order to increase motor efficiency & life. Power factor shall be near unity regardless of speed or load.

VFD shall preferably be provided balanced DC link reactor to minimize power line harmonics. VFDs without DC link reactor shall provide a 3% impedance line reactor.

Input & output power circuit switching can be done without interlocks or damage to VFD. Following provisions shall be customer modifiable:

Motor acceleration & deceleration time, minimum & maximum voltage frequency

1.7 DRIVE

The compressor shall be driven directly or through speed increasing gears as required. The gears and pinions shall be pressure lubricated. The gears shall be provided with oil filter and submerged oil pump. The gears should be of helical type with crown teeth designed such that more than one tooth is in contact at all times to provide even distribution of compressor load and quiet operation. Gears should be integrally assembled in the compressor motor support and be film lubricated. Each gear should be individually mounted in its own journal and thrust bearings to isolate it from impeller and motor sources.

1.8 CAPACITY CONTROLS

The compressor shall be equipped with an automatic suction damper or inlet guide vanes control, for regulating its capacity. The positioning of the damper shall be done by means of thermostatically actuated electronic temperature controller differential type with its sensing elements in the outgoing chilled water lines. The automatic damper will maintain the constant temperature of chilled water. It should be possible to go down to 20% of full load even at constant entry condenser water temperature. It should also be stable upto 20% unloading at constant entry condenser water temperature of design CW temp +4 deg F. Manufacturer must not use hot gas by pass for capacity modulation.

Compressor and motor sole plates, anchor bolts and sleeves and necessary vibration isolator pads must be included.

1.9 BEARINGS

The compressor shall incorporate the necessary design features, which eliminate both the axial and radial thrusts. The bearings shall be fabricated of aluminium alloy / white metal and precision bored and axially grooved. The bearings shall be pressure lubricated during operation and shall be completely sequenced and interlocked with the start up of the machine in such a way that the oil pump starts earlier than the machine and the machine automatically starts after some lag

time provided the oil temperature and pressure are maintained during the start-up period. On stopping the machine, oil pump should stop only after the machine has completely stopped.

1.10 LUBRICATION SYSTEM

The lubrication system should form an integral part of the compressor assembly and shall enforce complete force feed lubrication (at a controlled pressure and controlled temperature) to all bearing surfaces under any speed conditions, at start-up, at shut down and during operation at various loads. Oil cooler shall be factory assembled and preferably refrigerant cooled only. Provision shall also be made to take care of lubrication during coast down cycle upon intermittent failure of power. Thus full lubrication must be available to the machine during acceleration and deceleration periods. Further it should include the followings:

High accuracy oil filters.
Low oil pressure cutout.
Oil coolers and oil heaters (with built-in-thermostat) to aid maintaining constant temperature.
Oil level indicator.
Oil pressure control with pressure gauges and thermometer.
The compressor shaft seal shall consist of a spring loaded precision carbon ring high temperature elastomer "O" ring static seal and must effectively prevent the leakage of refrigerant along the shaft during shut down periods. During operation an oil film under pressure should prevent outward leakage of refrigerant.

1.11 WATER –COOLED CONDENSER AND EVAPORATOR (COOLER)

SHELLS AND WATER BOXES

The evaporator and condenser shells will be of rolled carbon steel plate with fusion welded seams. Removable compact water boxes of cast iron or welded steel with stub-out water connections shall be provided to permit access for tube cleaning and replacement. Shell & Water boxes of condenser & evaporator shall be designed for 150 psig working pressure or as mentioned in the BOQ. In tall buildings working pressure may be 300 psig or more as specified in the BOQ. The tubes shall be finned from outside having spiral ridges from inside, roller expanded into the tube sheets providing a leak proof seal. The tube material will be copper, intermediate steel tube support should be provided at intervals not exceeding 1200 mm.

EVAPORATOR (CHILLER)

The Chiller shall be in accordance with ASME / GB / PED and provided with eliminator to prevent liquid carry over to the compressor. The Chiller shall be provided with liquid level sight glass and a relief device (of the busing type) to prevent excess pressure in the heat exchanger. The Chiller shall be horizontal, Shell and tube flooded type, provided with the following connections and accessories:

Refrigerant inlet and outlet pressure gauges.
Water inlet and outlet connections with industrial type thermometers.
Drain and vent connections with stop valves.
Pressure gauges on Water inlet and outlet connections.
Tubes shall be of copper. Tube thickness shall be 0.635 mm at root of fins & 1.2 mm at plain ends.

Chiller shall be insulated with adequate thickness of nitrile rubber insulation. The insulation shall be applied in such a manner that water boxes and covers shall be removable without damaging it.

CONDENSER

The condenser shall be in accordance with ASME / GB / PED and horizontal, shell and tube type. The condenser shall be complete with the following & accessories:-

Refrigerant inlet and outlet pressure gauges.
Liquid level sight glass.
Water inlet and outlet connections with industrial type thermometers.
Drain and vent connections with stop valves.
Pressure gauges on water inlet and outlet connections & Descaling valves.
Tubes shall be of copper. Tube thickness shall be 0.635 mm at root of fins & 1.2 mm at plain ends.

The cooler and condenser shall include ASME "U" stamp and nameplate certifying compliance with the ASME Section VIII, Division 1 code of unfired pressure vessels or approved local equivalent requirements.

Cori-rubber or equivalent make metallic bellows shall be provided both at inlets and outlets of Chillers to minimize transmission of vibration to connected piping system.

1.12 MICRO-PROCESSOR / MICRO-COMPUTER CONTROL PANEL

The chilling package shall be equipped with microprocessor computer control panel in a locked enclosure, factory mounted, wired and tested. The control panel shall include a alpha-numeric back-lit Liquid Crystal Display (LCD) showing all system parameters in the English language with numeric data in MKS units.

Digital programming of essential set points through a colour coded, tactile-feel keypad shall include:

(a) Chilled / Condenser water outlet temperature
(b) Chilled / Condenser water inlet temperature
(c) Percent current limit
(d) Pull-down demand limiting
(e) Seven-day time clock for starting and stopping chilling package, pumps and cooling tower or condenser fan complete with local holiday schedule
(f) Remote re-set temperature range
(g) Regulations of the Chilled water temperature

All safety and cycle shut-downs shall be annunciate through the alpha-numeric display and consist of day, time; cause of shut-down and type of re-start required safety shutdowns shall include:

(a) High oil pressure
(b) High compressor discharge pressure
(c) Low evaporator pressure
(d) Motor fault

(e) Sensor malfunction

Cycling shutdowns shall include:

(a) Low chilled water outlet temperature
(b) Low oil temperature
(c) Chilled water low flow or interruption or chilled water pump failure
(d) Condenser fan failure
(e) Power fault
(f) Internal time clock
(g) Anti-recycle

System operating information shall include:

(a) Chilled water inlet and outlet temperatures
(b) Condenser water inlet and outlet temperatures
(c) Evaporator and condenser refrigerant pressure
(d) Oil pressure and oil filter differential pressure
(e) Oil temperature and oil level
(f) Suction and discharge temperatures
(g) Slide valve position
(h) Chilling package status
- Start-up sequence status
- Shut-down and operational status
(i) Number of compressor starts
(j) Total hours of operation
(k) Hours since last start
(l) Time of last start and time of last stop
(m) Compressor motor current
(n) Fault history

Microcomputer controls shall provide adjustable rate at which the chiller is allowed to load from one minute to over four hours.

Controls shall be furnished to avoid nuisance chiller system cycling due to transient high and low pressure conditions by not allowing compressor to load for a safe period of time. If the condition persists, the unit will be shut down automatically. During this period, the display will denote high or low pressure as the governing chiller control factor.

A four position key switch shall be furnished to provide a choice of independent control modes of operation. These include local, program, remote and service mode.
Any input that could potentially harm the machine shall be rejected and the operator immediately advised via display message.
Battery backup shall be provided to keep all set points in memory for a minimum of one month in case of power failure.

Indication of heat exchanger efficiency shall be displayed to identify tube cleaning /water treatment requirements.

Panel shall be furnished with a terminal block to accept a one to eleven second pulse width signal for continuous remote reset of leaving chilled water temperature and power demand limiting.

Field interlocks shall be provided to allow remote differentiation between cycling and safety shutdowns. Separate contact closure shall also be furnished to indicate the chiller will start (all safeties and cycling devices satisfied) when a remote start signal is received.
Security access shall be provided to prevent unauthorized change of set points and to allow authorised local or remote control of the chilling package.
Entire Chiller package including VFD, Microprocessor control panel shall be suitable for operation in ambient temperature upto 40^{O}C.

1.13 INTERFACE WITH BUILDING MANAGEMENT SYSTEM

For the integration of Microprocessor Panel of the Chilling machine with the Building Management System, an Interface Control Document shall be developed and provided by the Chiller Contractor.

- ✓ Hardware, Software protocol of Chiller Microprocessor panel
- ✓ Communication structure relating to collection of message / event information
- ✓ Description of the formatted packets / blocks of data which construe controller commands / responses
- ✓ Complete overview of the system
- ✓ All information described above to be available at one point
- ✓ Linking of all Chiller Microprocessor panels for communication between panels. Additionally, single point gateway shall be provide for high level integration with read / write capability to third party BMS
- ✓ The output shall be open protocol either BACnet.

1.14 PAINTING

Painting shall be as per subcontractor's standard.

1.15 REFRIGERANT

The Chiller shall utilize Eco-friendly Refrigerant R-134a.

1.16 INSTALLATION AND COMMISSIONING

Supervision of Commissioning and the initial start up shall be by factory-trained representatives of the equipment manufacturer, who have had extensive experience with the particular type of machine being installed.

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

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

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

(a) Chiller capacity

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

(b) Commissioning Tests

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

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

1.17 CHILLER PERFORMANCE TESTS

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

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

After assembly and pressure testing the chiller shall be tested on the following (in accordance with AHRI)

- Full load capacity.
- Capacity control range as specified and stability of operation at minimum load.
- Efficiency at full load and partial load. Readings of chiller performance at 100% 75% 50% 25% and minimum loadings are required.
- Safety device activation.
- Pressure drop across evaporator and condenser.
- The contractor shall submit the test schedule at least one (1) month before the proposed date of testing.

1.18 HARMONIC FILTERATION , RFI & EMC FILTERATION

The chillers/chiller switchboard shall be equipped with harmonic filtration to filter any harmonics generated from the Chiller plant.

Chiller VFD shall have passive harmonic filters comprising LC circuit with inductance and capacitance to achieve THDI not more than 25%.

Passive filtration shall be part of / inclusive in VFD enclosure / VFD Panel.

VFD's for sensitive installations, must have inbuilt active harmonic filter to restrict THDI & THDV to 5% at all loads at source. These installations are those where life and critical data communications are of high importance ,like:

- Hospitals
- Airports
- Electronic Industry
- Data centres
- Communication centres

Display of phase wise THDI & THDV must be available on chiller micro processor panel.
These installations Must have 'C1' category of RFI & EMC filters for 50 meters of cable length.
For these above mentioned critical applications, if chiller motors are more than 90Kw, then 'C2' category of filters to be used if ' C1' is not available.

VFD's for normal buildings and others similar installations shall have 'C3' category of RFI & EMC filter for Chillers.

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TECHNICAL REQUIREMENTS

Sl. No.	General Description		Requirement
1.	NUMBER REQUIRED		
2.	LOCATION		Indoor
3.	CAPACITY REQUIRED AT SPECIFIED DESIGN CONDITIONS PER CHILLING PACKAGE		As per requirement
4.	REFRIGERANT		R-134a
5.	MAXIMUM IKW/TR AT FULL LOAD		As per BOQ.
6.	MAXIMUM NOISE LEVEL AT A DISTANCE OF 1.0 METRES AT ALL LOADS		< 85 dba.
7.	BMS COMPATIBILITY		Required
8.	**COMPRESSOR**		
8.1	TYPE		Centrifugal
8.2	SEMI-HERMETIC / /OPEN		Acceptable
8.3	SINGLE / MULTI COMPRESSOR		
8.4	DRIVE: DIRECT / GEAR		Acceptable
8.5	DRIVE GUARD		Required IF APPLICABLE
8.6	LUBRICATION: FORCED FEED WITH AN OIL PUMP/DIFFERENTIAL PRESSURE		Required
8.7	CAPACITY CONTROL: STEP / STEPLESS		Stepless 100 – 20 % even at constant entry condenser temp.
9.	**CHILLER**		
9.1	TYPE: SHELL AND TUBE, FLOODED / DX		Acceptable
9.2	LIQUID TO BE COOLED		Water
9.3	CHILLED WATER QUALITY		Potable water
9.4	CHILLED WATER INLET TEMPERATURE		As per BOQ
9.5	CHILLED WATER OUTLET TEMPERATURE		As per BOQ
9.6	CHILLED WATER FLOW PER CHILLING PACKAGE		…….. USGPM
9.7	FOULING FACTOR: WATER SIDE		As per BOQ
9.8	CHILLER INSULATION		….. thick nitrile rubber
9.9	MAXIMUM WATER SIDE PRESSURE DROP		Max. 8 M
10	**CONDENSER**		
10.1	TYPE: WATER COOLED, TUBE AND SHELL		Acceptable
10.2	CONDENSER WATER QUALITY		Good Quality Water
10.3	CONDENSER WATER INLET / OUTLET TEMPERATURE		As per BOQ

Sl. No.	General Description		Requirement
10.4	FOULING FACTOR: WATER SIDE		As per BOQ
11	CONDENSER WATER FLOW PER CHILLING PACKAGE		…….. USGPM
12	MAXIMUM PRESSURE DROP ACROSS CONDERSER SIDE		Max. 8 M

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DATA TO BE FURNISHED BY THE CONTRACTOR ALONG WITH OFFER AT AHRI & DESIGN CONDITIONS

Sl.No	Equipment		
1.	**Water Cooled Chilling Machine**		
1.1	Unit information / Origin		
1.1.1	Machine No.		
1.1.2	Make/Model		
1.1.3	Nominal Capacity TR – each		
1.1.4	No. of compressors per machine		
1.1.5	Leaving / Entering Chilled Water Temperature - °F		
1.1.6	Operating Condensing Temperature- °F		
1.1.7	Compressor Suction Temperature- °F		
1.1.8	Capacity at Design Operating Conditions		
1.1.9	Overall Dimension – L x W x H – mm		
1.1.10	Overall Weight – Kgs		
1.1.11	Operating Refrigerant Charge - Kgs		
1.1.12	Noise Level at 1 Metre from the Unit - dBA		
1.2	**Compressor(s)**		
1.2.1	Compressor Type:		
1.2.2	Construction (semi hermetic)		
1.2.3	Manufacturer's Name and Model		
1.2.4	Refrigerant		
1.2.5	Cylinder/Screw data		
1.2.6	Speeds (Operating/Max.)	RPM	
1.2.7	Operating condensing and suction temperatures	°F	
1.2.8	Capacity at Design conditions.	TR	
1.2.9	KW at operating conditions	KW	
1.2.10	Motor losses	%	
1.2.11	Other losses if any	%	
1.2.12	Motor intake power	KW	
1.2.13	KW per TR at operating conditions	KW	
1.2.14	Capacity control – automatic or otherwise **(Enclose description)**		
1.2.15	No. of steps of capacity control		
1.2.16	Capacities and corresponding power consumption values		

	Load 100% 75% 50% 25%	Capacity – TR	IKW/TR (as per AHRI)	KW/TR (Constant condenser entering water temp, constant chilled water In/Out temp)

1.3	**Motors**		
1.3.1	Manufacturer's Name		
1.3.2	Type of motor		
1.3.3	Motor KW/rpm		
1.3.4	Rated current	Amps	
1.3.5	Motor efficiency	%	
1.3.6	Starting current with type of starter offered		
1.3.7	Model / Frame size		
1.4	**Starter**		
1.4.1	Type		
1.4.2	Make		
1.4.3	Whether single phase preventor included		
1.4.4	Whether over load relay included		
1.5	**Drive**		
1.5.1	Type of drive		
1.5.2	Any special requirements		
1.6	**Condensers (Water-Cooled)**		
1.6.1	Manufacturer's Name		
1.6.2	Dimensions – L x B x H mm		
1.6.3	Condenser water Entering Temperature - °F		
1.6.4	Condenser water Leaving Temperature - °F		
1.6.5	Discharge temperature - °F		
1.6.6	Fouling Factor		
1.6.7	ASME STAMPED (YES / NO)		
1.7	**Evaporator or Cooler**		
1.7.1	Type of Chiller (dx or flooded)		
1.7.2	Shell OD – mm		
1.7.3	Overall length – mm		
1.7.4	Overall weight – Kg.		

1.7.5	No. of tubes	
1.7.6	Tube OD – mm	
1.7.7	Nature of tubes (Whether integrally finned or tubes carry inserts)	
1.7.8	Length of tube between tube sheets - mm	
1.7.9	Material of tube	
1.7.10	Material of shell	
1.7.11	Minimum operating charge of refrigerant - Kg	
1.7.12	Flow rate – Lpm / Gpm	
1.7.13	Leaving water temperature - °C / °F	
1.7.14	Entering water temperature - °C / °F	
1.7.15	No. of passes	
1.7.16	Tube velocity – mps /fps	
1.7.17	Pressure drop – Water – Kg / Sq.Cm or Ft of water	
1.7.18	Fouling Factor	
1.7.19	ASME STAMPED (YES / NO)	
1.7.20	MIN FLOW POSSIBILITY IN CASE OF VARIABLE PRIMARY FLOW (30 % OF DESIGNED FLOW)	

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

1. Quality Assurance Plan (QAP).
2. Dimensioned general arrangement drawing showing all accessories, mounting details, nozzle locations, etc. for the water-cooled Screw Chiller package.
3. Foundation drawing with static and dynamic loading data, pocket details, foundation outline, etc.
4. Cross-sectional drawings of all items with part list and materials of construction.
5. Power wiring and control wiring diagrams.
6. Operation and maintenance manual.
7. AHRI certified performance sheets as below.
   - 4 point performance sheet at design conditions along with complete model no and VSD model.
   - 4 point performance sheet at AHRI Conditions
   - 4 point performance at Const. ECWT conditions
   - 10 point sound reports at Const. ECWT conditions

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DATA SHEET - B

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

(WATER COOLED CHILLERS)

No	Description	Unit	Time			Date			Remarks
1.	COMPRESSOR		10.00	12.00	14.00	16.00	18.00	20.00	
a.	Suction pressure	Kg/cm²							
b.	Discharge pressure	Kg/cm²							
c.	Oil pressure	Kg/cm²							
d.	Suction temperature	°F							
e.	Condensing temperature	°F							
f.	Starting current	Amps							
g.	Consumed current	Amps							
2.	CONDENSER								
a.	Entering water temperature	°F							
b.	Leaving water temperature	°F							
3.	COOLER								
a.	Water temperature at inlet	°F							
b.	Water temperature at outlet	°F							
c.	Pressure at inlet	Kg/cm²							
d.	Pressure at outlet	Kg/cm²							
4.	SAFETY CHECKS								
a.	High oil pressure	N: Kg/cm² A: Kg/cm²							
b.	High compressor discharge pressure	N: Kg/cm² A: Kg/cm²							

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DATA SHEET - B

CHECKLIST AND PERFORMANCE TEST DATA TO BE PROVIDED AFTER INSTALLATION

(WATER COOLED CHILLERS)

No	Description	Unit	Time			Date			Remarks
c.	Low evaporator pressure	N: Kg/cm² A: Kg/cm²							
d.	Low chilled water outlet temperature	N: ºC A: ºC							
e.	Low Oil temperature	N: ºC A: ºC							
f.	Chilled water flow	GPM							
g.	Power fault								
h.	No. of compressors in operation								
i.	Total hours of operation								
j.	Hours since last start								
k.	Any fault history								
l.	No Refrigerant Leaks								
m.	Purge Cycle normal								
n.	Waste Oil, Refrigerant properly disposed of and spare refrigerant properly stored								
o.	Any condensation problems								

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SECTION-B. VFD

1.1 SCOPE

This specification covers the general design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, delivery at site, installation, testing, commissioning and carrying out performance test at site of Variable Frequency Drives.

1.2 CODES and STANDARDS

The design, materials, construction features, manufacturer, inspection, testing and performance of variable frequency drives shall comply with all currently applicable statues, regulations, codes and standards in the locality where the system is to be installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility. In particular, the air distribution system shall conform to the latest edition of following standards.

1.3 GENERAL REQUIREMENTS

- ✓ 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.
  - ✓ The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered design.
- ✓ The VFD and its options shall be factory mounted and tested as a single unit under full load before dispatch.
- ✓ The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. VFD shall be manufactured in ISO 9000, 2000 certified facilities.
- ✓ The VFD shall be CE marked and conform to the European Union Electro Magnetic Compatibility directive.
- ✓ The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.
- ✓ The manufacturer shall have been engaged in the production of this type of equipment for a minimum of thirty years.
  - ✓ The frequency converter shall be supported locally by the manufacturer who will provide full technical support, spares holding and troubleshooting capability from their own local facility. A training course shall be provided by the manufacturer to the consultant / contractor / maintenance engineers.
- ✓ To ensure adequate technical and factory support, VFDs manufactured by others and brand labeled shall not be acceptable.

1.4 TECHNICAL REQUIREMENTS

The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating

When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

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

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

VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

IEEE519, 1992 recommendations shall be used for the basis of calculation of total harmonic distortion (THD) at the point of common coupling (PCC). On request VFD manufacturer shall provide THD figures for the total connected load. The contractor shall provide details of supply transformer rating, impedance, short circuit current, short circuit impedance etc to allow this calculation to be made.

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

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

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

A programmable automatic energy optimization selection feature shall be provided as standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.

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

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

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

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

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

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

1.5 PROTECTIVE FEATURES

A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.
Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.

If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.

The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

Protect from output switching : The VFD shall be fully protected from switching a contactor / isolator at the output with out causing tripping e.g.: for switching on/off the isolators of the AHU / ventilation fans / pumps near the motor with VFD in ON mode.

The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.

When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

1.6 INTERFACE FEATURES

Hand, Off and Auto keys shall be provided on the control panel to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.

There shall be an "Info" key on the keypad. The Info key shall include "on-line" context sensitive assistance for programming and troubleshooting.

The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.

Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.

All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.

Display shall be programmable to communicate in multiple languages including English, Chinese, Korean, Japanese, Thai and Indonesian.

A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual Fan, Pump, and Compressor menus specifically designed to facilitate start-up of these applications.

A three-feedback PID controller to control the speed of the VFD shall be standard.

This controller shall accept up to three feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints and to automatically select either the maximum or minimum deviating signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.
The VFD shall be able to apply individual scaling to each feedback signal.

For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.

The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.

The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide setpoint reset.

Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

Five simultaneous meter displays shall be available. They shall be selectable from (at a minimum), frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, feedback signals in their own units, among others.

Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a "wake-up" feedback value that will cause the VFD to start. To avoid excessive

starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.

A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.

VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°F). Examples can be room temperature in ^0C , return air temperature in ^0C , supply air temperature in ^0C, CO_2 concentration in ppm, pressure in bar, differential pressure in PSI etc.

VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

<u>Standard Control and Monitoring Inputs and Outputs</u>

Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.

Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.

Each relay shall have an adjustable on delay / off delay time.

Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.

Each shall be independently selectable to be used with either an analog voltage or current signal.

The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.

A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.

The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,

One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal

supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.

It shall be possible to read the status of all analog and digital inputs of the VFD through serial bus communications.

It shall be possible to command all digital and analog output through the serial communication bus.

Optional Control and Monitoring Inputs and Outputs

It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.

These modules shall use rigid connectors to plug into the VFD's control card.

The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.

Modules may include such items as:

Additional digital outputs, including relay outputs

Additional digital inputs

Additional analog outputs

Additional analog inputs, including Ni or Pt temperature sensor inputs

It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

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

A real-time clock shall be an integral part of the VFD.

It shall be possible to use this to display the current date and time on the VFD's display.

Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and

others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

All VFD faults shall be time stamped to aid troubleshooting.

It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.

The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

Comparators for comparing VFD analog values to programmed trigger values

Logic operators to combine up to three logic expressions using Boolean algebra

Delay timers

A 20-step programmable structure

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

1.7 SERIAL COMMUNICATIONS

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

Metasys N2

Modbus RTU

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

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

1.8 ADJUSTMENTS

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

Four independent setups shall be provided.

Four preset speeds per setup shall be provided for a total of 16.

Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds.

Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.

If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.

The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

An automatic "start delay" may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.

Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

1.9 OPTIONAL FEATURES

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

1.10 SERVICE CONDITIONS

Ambient temperature at full speed, full load operation with continuous drive rated output current:

-10 to 45°C for ratings upto 90 kW without derating

-10 to 40°C for ratings 110 kW and higher without derating

Relative Humidity : 0 to 95%, non-condensing.

Elevation : Up to 3,300 feet without derating.

AC line voltage variation : ± 10% of nominal with full output.

VFD Enclosure protection : IP 55 with Mains Disconnect switch, integral, with no additional cabinets. – Not applicable. Protection shall be for Indoor installation.

Side Clearances : No side clearance shall be required for cooling.

All power and control wiring shall be done from the bottom.

All VFDs shall be plenum rated.

All the contacts mounted on each VFD should be brought to the terminal blocks of each starter in order to enable BMS vendor to do termination of his cables. None of the terminations of the BMS cables be done directly to the VFD.

1.11 QUALITY ASSURANCE

To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

All optional features shall be functionally tested at the factory for proper operation.

1.12 SUBMITTALS

This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

SECTION-C. CHILLER PLANT MANAGER

System required: Chillers with VFD, primary pumping, secondary pumping with VSD and DP sensor, Cooling Towers with VSD.

Chiller Plant Manager:
The chiller controls shall be supplied with upto 6 nos. Chillers with a chiller lead/lag system. The control system shall automatically start and stop a lag or lead chiller system. If one of the chillers on line goes into a fault mode, the other chiller shall be automatically started.

The chiller lead/lag system shall allow manual rotation of the lead chiller, include load balancing, and a staggered restart of the chillers after a power failure.

A Chiller system Manager with inherent input/output capability shall be installed.

Chiller System Manager Control system shall be complete with required input/output to control up to Six (6) chillers on a common loop, primary and secondary pumping system and cooling Towers. The liquid crystal display specified for the chiller microprocessor shall be the only operator interface required to program, modify, change, enable, or disable the Chiller System Manager.

The Chiller System Manager shall provide:

- Staging of chillers
- Automatic lead/lag control of chillers based on system load.
- Lead/lag switching based on runtime, fixed rotation, calendar date, and/or outside air temperature.
- Capability to customize sequence for unequal sized chillers
- Capability to designate a chiller to perform “feathering functions”.
- Capability to start next available chiller in event of chiller alarm.
- Capability to perform chilled water system reset* based on outdoor air temperature chilled water system differential temperature or return chilled water temperature.
- Control of pumps, motorised valves and variable frequency drives via input/output modules.
- Interface to building demand meter for demand limiting via the optional Load shed Module.
- Data logging for chiller operating parameters via the optional Data Collection Module.

The chiller microprocessor and Chiller System Manager shall be capable of interfacing with a PC operator workstation supplied with chiller manufacturer software. The PC interface software shall include the ability to annunciate alarms, display dynamic graphics of the chiller plant, and display chiller plant reports. The chiller microprocessor shall be capable of communicating with other vendor supplied control devices as required for data logging, demand limiting, air side interface, and other control functions.

Capability of Optimum Start and Stop (OSS) program that will use data from the building on how long the building takes to warm up or cool down and adjust start and stop times automatically.
(*) Chilled Water Reset Strategy:

The controller provided shall have capabilities to provide:

Chilled-water reset that adjusts the chilled-water set point automatically to improve the efficiency of the chiller and thereby reducing the energy consumption of the chiller.

Usually, a chilled-water-reset strategy raises the set-point temperature when the building load is at less-than-design conditions. Producing warmer chilled water lessens the burden on the compressor, which means that the chiller consumes less energy.

Example: Consider a centrifugal chiller with entering- and leaving-water temperatures of 54°F and 44°F, respectively, at design conditions, and a maximum reset of 4°F. When the building load falls to 80 percent of design, the water temperature leaving the evaporator is reset upward, by 2°F, to 46°F. If the building load continues to drop, the set point is adjusted upward until the maximum reset set point of 48°F is reached (44°F design set point + 4-5°F maximum reset).

As a rule-of-thumb, each 1°F increase in the chilled-water temperature reduces the energy consumption of the chiller by an amount from 1 percent to 1.5 percent.

The optimal set points of the chilled water system in real time can be arrived upon based on building data / feedback from Client's operations. With the optimal set points of VSD secondary pump speed and control valve positions, the minimal required chilled water flow rate can be maintained in water distribution systems. At the same time, designed chilled water return temperature can be achieved by the appropriate coil water flow rates determined by control valves.

Chilled Water Supply Temperature can be reset based on:

- Outside Air temperature, Chilled Water Return Temperature, 2-way valve position, Supply air temperature etc. of AHUs
- Reset of Cond.w. supply temperature based on outside air wet bulb.
- Reset Cond.w. flow on outside air wet-bulb or Chiller Load (%)
- Feedback from opening % of FA dampers for each AHU room.
- Verify that the chilled water supply temperature reset does not adversely impact supply air dehumidification.

Optimise resets based on operational feedback.

The chilled water rest functions and chiller plant manager functionalities shall be subject to availability or limitations in reputed chiller OEM provided software or product.

- BMS system shall have the provision to share parameters like "HVAC tonnage, HVAC energy consumption, all temperature, pressure, valve & damper position". CPM system shall accept these parameters into its model.

SECTION INCLUDES

1 **General Description**
2 **Architecture/Communication**
3 **Operator Interface**
4 **Application and Control Software**
5 **System Controllers**
6 **Equipment Controllers**
7 **Input / Output Modules**
8 **Auxiliary Control Devices**
9 **System Tools**

1.1 General Description

1.) The Chiller Plant Optimizer shall be indicated to control all the equipment's as per IO summary attached.
2.) Network Control Engine and direct Digital Control (DDC) technology shall be used to provide the functions necessary for control the mechanical systems. All microprocessor should be BTL listed & UL certified.
3.) The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple user shall have access to all valid system data & the system shall be web based enabled.
4.) Control system should be such that all mechanical equipment's will be able to operate on a standalone basis. In case of power failure or communication failure the system should keep on working on a stand-alone basis.
5.) Communication between the controllers shall be on Bacnet IP/ MSTP or Modbus.
6.) The equipment's to be monitored and controlled includes:
a.) Control of Chillers, Primary Pumps, Condenser Pumps, Cooling Tower Fans and Motorized Valves.
b.) Synchronization shall be achieved for chillers, pumps and cooling tower operation and to enable sequential operation to achieve equal operating time and take care of load patterns and shall be as per specification.
c.) Measurement and monitoring of Chilled Water Temperature.
d.) CPM should have LED display & facilities like Time schedule, Trends & Alarms.

SYSTEM HARDWARE:

CPM shall use an open architecture and fully support a multi-vendor environment. To accomplish this the CPM should support open communication protocol standards and integrate a wide variety of 3rd party devices. The system shall be compatible to be used over internet/ web based.
The system shall be designed into three tiers and contain a field tier (the tier that contains all of the field level controllers and application specific controllers), an automation tier and an enterprise tier. Two tier application is not acceptable.
CPM should consists of the following hardware and software:

1.) Standalone Network Supervisory Engine.
2.) DDC Field Equipment Controllers and BTL certified Input and Output Module
3.) Workstation and data storage software.

Standalone Network Automation Engine

1.) The controllers shall be 32 bit microprocessor based standalone controller.
2.) The controllers shall be networkable over peer to peer communication complete with lockable mounting cabinets duly powder coated connector strip, internal wiring and space to house controller & relays, connector strip, MCB, internal wiring., master only DDC controllers as described.
3.) Controllers should support Bacnet standard MSTP Bus Protocol & shall be BTL certified.
4.) PICS statement shall be provided for the controllers used.
5.) Network engine shall be able to access minimum 5 simultaneous users.
6.) Network engine shall be web based and can be browsed from any computer in the IP network.

7.) Network engines should have inbuilt IO points, functionally able to act as a DDC Controller as well as a supervisory controller.
8.) Network engine should support integration of third party protocol.
9.) Network engine should support DHCP function for IP addressing.

DDC Field Equipment Controllers and BTL certified Input and Output Module

1.) The controllers shall be 32 bit microprocessor based standalone with windows based operating system.
2.) The DDC controllers shall be programmable and capable of extensive measuring & monitoring functions.
3.) DDC controllers should be UL Listed with BTL certificate.
4.) DDC shall support **PID** and **PRAC** logic (Auto Process Tuning).
5.) DDC shall support inbuilt sequencing operation to achieve equal operating time and take care of load patterns and shall be as per specification
6.) DDC controllers shall have a port for hand held Portable Operated Terminal (POT).

Workstation and data storage software

1.) System shall provide a real time pre-engineered database incorporating Analog & Digital inputs.
2.) Historian data should be provided against the points defined in the database. Time schedule, Trends & Alarms should be an inbuilt feature of the engine.
3.) Events and audit report should be a part of the engine.
4.) CPM software should be licensed for 5 users.
5.) Server software should be web based and can be browsed from any computer in the IP network..
6.) System should have a 3D view and user friendly graphics.
7.) CPM shall be able to integrate with BMS using any standard open protocol.

1.2 Architecture/Communication

1.3 This project/SYSTEM shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be of IP type and utilize [BACnet IP] communications. OPERATOR INTERFACE

A. Furnish [1] PC based operator interface as shown on the system drawings. Each operator interface shall be able to access all information in the system. Operator interfaces shall reside on the same high-speed network as the System Controller(s).

1) Each PC based operator interface shall include the following:
Hardware type
1) PC
Operating Systems
1) Windows Latest
Minimum Hardware
2) As required by the OEMs system Operator Interface
a) The operator interface shall be accessible via a web browser.
b) Access to the operator interface shall not require any "plug-ins" (i.e. JAVA Runtime Environment (JRE), Adobe Flash) in addition to the web browsers identified below.
c) The operator interface shall support the following Internet web browsers:
1) [Optional] Internet Explorer 10.0+
2) [Optional] Firefox 29.0+
3) [Optional] Chrome 35.0+
d) The operator interface shall support the following mobile web browsers:
1) [Optional] iOS (iPad/iPhone) V6.0+
2) [Optional] Android (Tablet) V4.3+
3) [Optional] Android (Phone) V2.3+
3) Mobile App Operator Interface
a) Mobile App Operator Interface shall support the following Operating systems
1) Apple iOS 6
2) Apple iOS 7
3) Android V2.3
4) Android V4.3
5) Android V4.4
b) The operator interface shall support system access on a mobile device via a mobile app to:
1) Alarm log
2) System Status

3) Equipment status
4) Space Status
5) Standard Equipment graphics

c) The operator interface shall support actions on a mobile device via a mobile app to:

1) Override set points
2) Override occupancy
3) Acknowledge Alarms
4) Comment on Alarms

d) System Security

1) Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
2) User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
3) Each operator shall be allowed to change their user password
4) The System Administrator shall be able to manage the security for all other users
5) The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.
6) User logon/logoff attempts shall be recorded.
7) The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
8) All system security data shall be stored in an encrypted format.

e) Database

1) Database Save. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC.
2) Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

f) On-Line Help and Training

1) Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
2) On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.

g) System Diagnostics

1) The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
2) The failure of any device shall be annunciated to the operators.

h) Equipment & Application Pages

1) The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:

a) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:

i) Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These graphics shall show all points dynamically as specified in the points list.

ii) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.

b) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.

c) Historical Data (As defined in Automatic Trend Log section below) for the equipment or application without requiring a user to navigate to a data log page and perform a filter.

i) System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.

1) Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
2) Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
3) Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
4) Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
5) Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

j) Custom Graphics

1) The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.
2) Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.
3) Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
4) Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.

k) Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.

l) Manual Control and Override.

1) Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
2) Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.

3) Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
4) Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.

m) Engineering Units
1) Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
2) Unit selection shall be able to be customized by locality to select the desired units for each measurement.
3) Engineering units on this project shall be [IP] [SI].

4) Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:
a) Create a new schedule, defining the default values, events and membership.
b) Create exceptions to a schedule for any given day.
c) Apply an exception that spans a single day or multiple days.
d) View a schedule by day, week and month.
e) Exception schedules and holidays shall be shown clearly on the calendar.
f) Modify the schedule events, members and exceptions**.**

5) Trend Logs
a) Trend Logs Definition.
1) The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.
2) The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section.
b) Trend Log Viewer.
1) The operator interface shall allow Trend Log data to be viewed and printed.
2) The operator interface shall allow a user to view trend log data in text-based (time – stamp/value).
3) The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.
4) Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
5) Each data point trend line shall be displayed as a unique color.
6) The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
7) The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
c. Export Trend Logs.
1) The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.

6) Alarm/Event Notification
a) An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
b) Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.

2) Alarm/event messages shall use full language, easily recognized descriptors.
3) An operator with the proper security level may acknowledge and clear alarms/events.
4) All alarms/events that have not been cleared by the operator shall be stored by the building controller.
5) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.

c) Alarm Processing.

1) The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
2) The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.

7) Reports and Logs.

a) The operator interface shall provide a reporting package that allows the operator to select reports.
b) The operator interface shall provide the ability to schedule reports to run at specified intervals of time.
c) The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:

CSV, HTML, XML, PDF

d) Reports and logs shall be readily printed to the system printer.
e) Provide a means to list and access the last 10 reports viewed by the user.
f) The following standard reports shall be available without requiring a user to manually configure the report:

1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
2) All Points in Override Report: Provide an on demand report showing all overrides in effect.
3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
4) Points report: Provide a report that lists the current value of all points
5) ASHRAE Standard 147 Report: Provide a daily report that shows the operating condition of each chiller as required by ASHRAE Standard 147. At minimum this report shall include:

[Note: ASHRAE Standard 147 Report compliance requires that optional equipment and monitoring features be provided on the associated chiller(s).]

a) Chilled Water (or other fluid) inlet and outlet temperature

b) Chilled Water (or other fluid) flow

c) Chilled Water (or other fluid) inlet and outlet pressures

d) Evaporator refrigerant pressure and temperature

e) Condenser refrigerant pressure and liquid temperature

f) Condenser water inlet and outlet temperatures

g) Condenser water flow

h) Oil pressure and temperature

i) Oil level (if applicable)

j) Compressor refrigerant discharge temperature

k) Compressor refrigerant suction temperature

l) Manual entry field for addition of refrigerant

m) Manual entry field for addition of oil

n) Manual entry field for vibration levels

o) Motor amperes per phase

p) Motor volts per phase

q) Purge exhaust time or discharge count

r) Ambient temperatures (dry bulb and wet bulb)

s) Date and time data logged

8) Chilled Water System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:

a. System mode of the chiller plant
b. Chiller enable/disable status
c. System supply water setpoint
d. System supply and return water temperature
e. System Chilled water pump status
f. System Chilled water flow
g. Bypass pipe flow rate (if applicable)
h. Messages as to when an additional chiller will be added or removed from operational sequence
i. Chiller or system failure information
j. Chiller rotation information
k. Override capabilities to force an added chiller, subtract a chiller, or change of sequence.
l. Control to remove a chiller from a sequence temporarily for service purposes.

9) Custom Graphic Editor. Provide the tools to create, modify, and debug custom graphics. The operator shall be able to create, edit, and download custom graphics at the same time that all other system applications are operating. The system shall be fully operable while custom graphics are edited, compiled, and downloaded.

1.4 *APPLICATION AND CONTROL SOFTWARE*

A) Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator interface.

1. **Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:**

a) Weekly Schedule. Provide separate schedules for each day of the week.

b) Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.

c) Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

d) Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less then and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

2. **Trend Log Application**

a) Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a BACnet Workstation for longer term storage.

1) Trend logs shall include interval, start-time, and stop-time.

2) Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.

b) Automated Trend Logs.

1) The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.

2) The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.

3) The following is a list of key measurements required for Automatic Trending:

3. **Alarm/Event Log**

a) Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.

b) Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.

c) An alarm/event shall be capable of triggering any of the following actions:

1) Route the alarm/event to one or more alarm log

a) The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.

2) Route an e-mail message to an operator(s)

3) Log a data point(s) for a period of time

4) Run a custom control program

4. Chiller Plant Control. Provide applications software to properly sequence the chiller plant to minimize energy use. This application shall perform the following functions:

a) The chiller plant control application shall have the ability to control up to 25 chillers as detailed in the sequence of operations.
b) This application shall be able to control both constant and variable flow systems including variable primary flow as well as parallel, series and decoupled piping configurations.
c) The chiller plant control application shall be able to control multiple chiller plants per site.
d) Diagnostics/Protection - The chiller plant application program shall be able to integrate individual chiller diagnostics into control action decisions.
e) Event Processing - All chiller plant control and status events shall be recorded, at the operator's selection, in the building management system event log to facilitate troubleshooting.
f) Alarm Indications - The chiller plant control status screens shall display chiller plant and individual chiller alarm messages.
g) Add/Subtract actions - The status screens shall provide information on when the next chiller add or subtract action will occur. The operator shall have the ability to manually force a chiller addition or a chiller subtraction.
h) Rotation of Chillers based on either runtime or schedule
i) Auto reset of chiller plant application after failure when reset at Chiller unit Control

1. **Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.**
2. **Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the operator interface.**
3. **Anti-Short Cycling. All binary output points shall be protected from short cycling**

1.5 *SYSTEM CONTROLLERS*

A. There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies described in Application and Control Software section.

1. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. The controller shall provide a USB communications port for connection to a PC
3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. All System Controllers shall have a real time clock.
5. Data shall be shared between networked System Controllers.
6. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
   a. Assume a predetermined failure mode.
   b. Generate an alarm notification.
   c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.

   Automatically reset the System Controller to return to a normal operating mode.
7. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 C to 50 C [-40 F to 122 F].

8. **Clock Synchronization.**
   a All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
   b All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
   c. All System Controllers shall automatically adjust for daylight savings time if applicable.
9. **Serviceability**
   a. Provide diagnostic LEDs for power, communications, and processor.
   b. The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
   c. All wiring connections shall be made to field removable, modular terminal connectors.
   d. The System controller shall utilize standard DIN mounting methods for installation and replacement.
10. **Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller**
11. **Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage**
12. **BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs.**

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SECTION-D. NON-POWERED AUTOMATIC TUBE CLEANING (ATC) SYSTEM

1. **Function -**The automatic tube cleaning system shall circulate cleaning medium through the condenser tubes, with each cleaning cycle to be completed within a minute followed by rinsing of the sponge balls in a swirling motion within the ball receptacle. The cleaning cycle shall be repeated once every 30 minutes or less.

2. **No Prime Mover** – The ATC system does not require the use of single phase or 3-phase motors to drive any pump, compressor or flow diverter to function. The automatic tube cleaning system operates using difference in water pressure in the cooling water system to circulate the cleaning balls.

3. **Ease of Maintenance** –

- The automatic tube cleaning system shall keep the condenser tubes free from scaling and fouling without the need for maintenance of moving parts such as those found in pumps, flow diverters and compressors. The automatic tube cleaning system operates with only a single motorized ball valve.
- Stainless Steel SS 304 ball valves with elongated handles shall be used for ease of closing the valves to isolate the automatic tube cleaning system during an emergency/maintenance and replacement of cleaning balls.
- Use flanged connection instead of threaded connection components for longer component life and easy maintenance or future repairs.

4. Minimal head loss –

- 4.1 The automatic tube cleaning system shall not have components or accessories inserted along the condenser cooling water supply and return pipes and the condenser tubes that will generate head loss greater than 0.4 psi. (subject to flow and pipe size).
- Use full ball valve for maximum cross-sectional opening passage through valve for better flow and lower head loss.
- The SS 304 Ball Catcher shall be funnel shaped, with inclined Rectangular -Slot Design, so sponge balls undergo a swirling effect and self-cleaning with negligible pressure drop. Other design Ball Catchers like mesh strainers, Y Strainers, flat inclined grid shall not be accepted.

5. Automatic Tube Cleaning System shall have double loops design for the cooling water supply to be separate with cooling water return.

The automatic tube cleaning system link pipe shall not allow warm water from the Condenser Return Pipe to re- circulate through the condenser tubing as this will increase the temperature of the cooling water entering the condenser, also, it carries the fouling debris from the previous cleaning cycle back into the same condenser tubes. Besides increasing the temperature of cooling water entering the condenser, the pumping of water from the condenser water return pipe back to the condenser water supply pipe, if significant enough, may upset the balance of condenser water flow resulting in vibration which may damage the piping in the long run. No mixing of supply and return condenser water.

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6. **Dedicated Chiller ATC** – Each Chiller should have dedicated non powered ATC for effective cleaning of condenser and maintaining Condenser Approach and also to have sufficient lifespan of sponge balls.

Common Unit for multiple chillers is not accepted, since performance won't be efficient, sponge balls life will be lesser, cleaning is uncertain, if system breakdowns due to any component failure all the chillers are affected.

7. **Durable and corrosion resistant** – The automatic tube cleaning system components shall be made of stainless steel SS304 which is resistant to scaling and able to withstand long term corrosion. Manufacturer shall supply all components: 4 Nos. Isolation ball Valves with elongated Handles, 2 Check Valves, 1 Ball Station with Transparent Lid, SS 304 funnel shaped Ball catcher.

8. **Easy replacement of consumables** – The procedure to replace the cleaning medium shall be simple and easy to carry out in less than half an hour with no downtime to chiller operation.

9. **No discharge of condenser water from the automatic tube cleaning process** – The use of automatic tube cleaning system shall not cause chemically treated/cooling water to be discharged during each cleaning cycle. No water loss. The product which has loss of water or mixes CDWS & CDWR shall not be accepted.

10. **Able to withstand high pressure** – The automatic tube cleaning system should ensure sustained safe working conditions and leak free operations.

11. **No additional fixtures, gadgets or accessories to be installed along the condenser tubes and on both ends of the condenser –** The automatic tube cleaning system does not impede flow along the condenser tubes, cause fouling and corrosion at both ends of the condenser; the original length of the condenser shall not be extended by altering the end covers of condenser.

12. **Link pipes shall not be joined by means of threaded components. Use PN 16 flanges and M16 bolts with locknuts–** The use of threaded components slows down the installation process and increases chances of pipe leaks especially when the water pressure is high. Should flanges be used, the gaskets shall be or marine grade. Instead use welded flanges, marine grade gaskets, bolts & nuts for easy repairs or replacement of faulty components. To meet the requirements of SCDF to ensure the system is able to withstand tremors, automatic tube cleaning system comes with PN 16 flanges to secure valves along the link pipes. In addition, M16 stainless steel bolts with locknuts are used to ensure the bolts do not get loosen by vibration and tremors.

13. **Micro-controller shall have the following features –**

- The interval between each cleaning cycle shall be set at **30mins** but can be adjusted, with programmable option to reduce the interval in cases of severe fouling in the condenser tubes.
- Shall be able to contact wire to Building Management System (BMS)
- Able to operate either on auto and manual mode.
- Power ON/OFF indicator lights
- Able to self-diagnose mechanical faults and produce a fault signal to activate blinking fault light when the motorized ball valve fail to open or close properly or on time
- Digital timer setting to adjust ball-rinsing duration, and ball-resting duration
- Digital counter to register number of completed cleaning cycles Actuator motor's microcontroller complies with IP65 (water resistant)
- Microcontroller can be linked/interfaced to the Building Management System (BMS) or Local Sequential Control (LSC) for real time monitoring and coded online communication for timely response.

14. **Visual inspection availability of cleaning medium –**The automatic tube cleaning system must provide an observation/view station which less than 15cm which enable maintenance staff to visually inspect the physical condition of the cleaning medium to ensure they are not worn out.

15. **Failure of system does not affect normal chiller operations** – In the event of failure, automatic tube cleaning system must allow for quick isolation from chiller plant while allowing chiller to continue operations.

16. **Cleaning balls shall be made of a porous elastomeric material with diameter equal or slightly greater than inner diameter of heat exchanger tubing. –** Undersized cleaning balls that merely bounce off the inner surface of condenser/ heat exchanger tubing in a touch and go fashion will not get to scour off the fouling deposits, hence are ineffective. Experimental trails have shown the effectiveness of cleaning balls made of spongy materials versus other non-porous stiff material. Sponge balls are also more effective in cleaning enhanced tubes.

17. **Low energy consumption --** Power consumption shall be ≤ 0.22 kW for the entire system.

18. **Compliance to Industry Certification & Standard (***related to product quality and management systems)* where such guidelines and certification exist in the country. Possessing relevant industry certification in Management Systems and Work Processes are important product quality indicators.

- Patent Registration at least locally and USA to provide assurance against patent infringement. Under the Singapore Patents Act (Cap 221,2005 Rev Ed) ("PA") Part 13, introducers (eg. consultants, trading companies etc) and/or the end users of infringing products, directly or otherwise, are just as liable as the manufacturer or supplier.
- Singapore Green Building Product "SGBP" (Certification for Auto Tube Cleaning System) with "Leader" rating (4 ticks).
- International Standard Organization (ISO9001:2015)
- International Standard Organization (ISO14001:2015)
- International Standard Organization (ISO45001:2018)

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GALGOTIAS UNIVERSITY

SECTION: 8

LIST OF APPROVED MAKES

LIST OF APPROVED MAKES – HVAC & CHILLER

Instruction to bidders:

a. Submit catalogues with the offers.
b. Final choice of makes among the approved list shall rest with the Client / Consultant.
c. Produce test certificates for equipment/material supplied with bills for certification.
d. Submittals and samples must be approved from Client / Project Managers / Architects / Consultants before procurement.

Sl. No.	EQUIPMENT/MATERIAL		APPROVED MANUFACTURER
A.	**HVAC ITEMS:**		HVAC
1	Air-cooled / Water-cooled Chillers (Screw / Scroll / Reciprocating / Centrifugal / Maglev)	:	Mitsubishi-Climaveneta / Daikin / Carrier
1.1	Automatic Tube Cleaning System	:	ENERGEO/CQM LYNCERV
1.2	Chiller Plant Manager	:	Mitsubishi-Climaveneta /Daikin
1.3	INTELLEGENT ADIABATIC COOLING SYSTEM (iACS)	:	ENERGEO/ GESS International FZC LLC
2	Cooling Towers		Paharpur / Bell /Advance / Nihon
3	Pump Sets		Armstrong / Armstrong
3-A	Plate Type Heat Exchanger	:	Danfoss / Alfa Laval
3-A1	District Cooling - Energy Transfer Station (ETS)	:	Danfoss
3-B	PAC & HSCU	:	Swegon / Stulz / Climaveneta
4	Side Stream Filter		Lakos / Algressy
5	Degasser-cum-Closed Expansion Tank-Pressure Maintaining Station		Reflex / Flamco
6	Dirt Separator		Reflex / Flamco
7	Chemical Dosing		Aquabird / Thermax
7-A	Electrochemical Scale Treatment	:	Elgressy / Enpar
8	AHU / TFA (DX & Chilled Water)	:	Edgetech / Daikin (Citizen) / Carrier
9	Media Air Filters (MERV-rated, Carbon filters)	:	Thermodyne / Purolator
10	Electronic Air Filters	:	Magneto / Honeywell
11	AHU & TFA Blowers - Centrifugal Fans / Axial Fans / Jet Fans / Plug Fans / EC Fans	:	Greenheck / Maico
10	'V'-Belt drive	:	Fenner / Dunlop
12	Chilled Water Coils / Hot Water Coils	:	Coil Co. / Edgetech / As per OEM
13	UVGI System for Air Treatment	:	Honeywell / Alfaa UV
14	Heat / Energy Recovery Wheel (H/ERW)	:	DRI (Bryair) / OSTBERG
15	Hot Water Generator	:	Anergy / Emerald
16	Heat Pumps	:	Mitsubishi-Climaveneta / Energen
17	DX System - Split Units (Heat pump) / VRV / VRF Systems	:	Samsung / Dunhumbush / Carrier / Toshiba / Daikin / Midea
18	Copper Refrigerant piping	:	Mexflow / Rajco
19	Sequential Controller	:	Proton
20	Air Cooled Package Units & Water Cooled Package Units / Roof Top Units (RTU)	:	Bluestar / Midea
21	FCU	:	Edgetech / Midea
22	Chilled Water Cassette Units	:	Caryaire / Midea
23	Motors	:	ABB / Bharat Bijlee / Crompton

24	MS 'C' class piping / GI 'B' Class Drain Piping	:	TATA / Jindal (Hissar) / SAIL
25	Heavy Duty PVC Drain Piping	:	Polypack / Supreme
26	PICV / PIBCV / PIDCV / High-rangeability valves / Automatic Balancing valves / Self-dynamic Balancing-cum-Control valves	:	Oventrop / Belimo / Danfoss
27	Manual Balancing Valves / Check Valves / Manual Butterfly Valves / Motorized Butterfly Valves / Ball Valves / Triple Duty Valves		VTM UTAM / National / Castle
28	Pot-Strainer	:	Sant / Emerald
29	Y-strainer / Suction Guide	:	VTM UTAM / National / Castle
30	BTU Meter	:	Axioma / Virtec
31	Flow Switch	:	Rapidcool / Anergy
32	Thermostat / Humidistat	:	Honeywell / Siemens
33	Pressure Guage / Temperature Guage	:	Anergy / Emerald
34	VFD's	:	Danfoss / Yaskawa
35	Modular Hanging / Supporting system (Channel, Threaded Rods & Clamps) / Wire Support system / Cushy foot mounts / VI Pads / Anchor Fasteners		Hira Walraven / Mupro
36	Flexible pipe connections / Bellows	:	Resistoflex / Victaulic
37	Modulating Motors	:	Belimo / Honeywell
38	GI Sheets (GSS)	:	TATA Steel / JSW
39	Aluminium Sheets / perforated sheets	:	Balco / Hindalco
40	Factory Fabricated Duct – Round, Oval, Rectangular - GI, MS, Aluminum	:	Asawa / Ductofab
41	Flexible Insulated Ducts	:	Caryaire / Asawa
42	Pre-insulated Glass wool (CFC / HCFC - Free) Ductboard	:	Twiga-Isover
43	Pre-insulated PIR (CFC / HCFC - Free) Ductboard	:	Asawa / Kingspan
44	Grilles / Diffusers / Dampers (UL Listed / non-UL) / Sound Attenuator / Air registers	:	Dynacraft / Greenheck
44.1	Linear Diffuser (Trimless – Side & Down Throw)	:	Trox
44.2	Jet Nozzles		Servax / Caryaire
45	Dampers Actuator / Modulating Motors	:	Belimo / Honeywell
46	Welding rods	:	Advani / L&T
47	Paints	:	ICI / Berger / Asian Paints
48	VAV / CAV	:	Delta-Synchro / Dynacraft
49	Fibre Glass (CFC / HCFC - Free) Insulation	:	UP Twiga
50	Class 'O' Nitrile rubber / EPDM (CFC / HCFC - Free) insulation	:	ALP Aeroflex / Hira
51	PUF / PIR	:	Asawa / BASF
52	Fire Sealing Compound	:	Vijay Fire Systems
53	Air Quality Monitoring		Honeywell / Magneto
53-A	Advance Oxidation Plasma Cell	:	Ultrapure/ Atmos Air
54	Fire Paint		Cischem / Feukem
55	Therma Fuser	:	Price/Acutherm/ Metal Industries Inc, USA / Thermal Products Corporation USA
56	Grooved DI Coupling	:	National / Victaulic
B.	**VENTILATION**		
1	Cabinet fan Ventilation units / Air washer (Package Type) & Scrubber Assembly (Sectionalized construction as per specifications)	:	Edgetech / Anemo Prime / E-flow

2	Ventilation Fans - Centrifugal Fans / Axial Fans / Jet Fans / Plug Fans / EC Fans	:	Kruger / Nicotra / Maico
3	Dry Scrubber ESP Units (UL Listed & UL Marked)	:	Trion / Honeywell
4	Air cooling pads	:	Munters / Bryair
5	'V'-Belt drive	:	Fenner / Dunlop
6	Propeller Fans / Inline Fans	:	Ostberg / Caryaire
7	Temprature sensors / Pressure sensors / Air sensors / CO sensors/ CO2 sensors / PM sensors / Water sensors / Hydrogen Sensors	:	Dwyer / Siemens
C.	**ELECTRICALS**		
1	MCCB's	:	Schneider: NSX Series / Hager
2	ACB's	:	Schneider: NSX Series / Eaton
3	MPCB's :	:	Schneider: Tesys Series / Eaton
4	MCB's, ELCB's, RCBO's & RCCB's, MCB DB's	:	Schneider –Acti-9 Series / Hager
5	HRC Fuses & Fuse bases	:	Schneider Electric / Siemens
6	Moulded Socket outlets / Weatherproof / Metal Clad Socket Outlets		Clipsal / Neptune-Bals
7	Industrial Socket in moulded enclosure / in powder coated sheet steel enclosure	:	Clipsal / Neptune-Bals
8	Weatherproof Enclosure		Hensel / Cape
9	Manual On Load 4P Change Over Switches	:	HPL Socomec / L&T
10	Contactors & O/L relays within built SPP	:	Schneider: Tesys Series / Siemens: 3TF Series
11	Auxiliary Relays for Control & tripping circuits for fire etc.	:	Schneider / Siemens
12	SPP	:	Minilec / L&T
13	Indication Lamps	:	Schneider Electric / Siemens
14	Push Buttons - Fire & Non-fire rated	:	Schneider Electric / Siemens
15	Selector Switches and Rotary Switches	:	L&T -Salzer / Kaycee
16	Electrical Terminal Blocks	:	Elmex / Connect Well
17	Meters - Digital / Multifunction / VAF / VA / V /A/ Hz / kWH meters (BMS / Non BMS compatible)	:	Schneider-Conzerv / Neptune Ducati
18	Meters - Analogue	:	Schneider-Conzerv / Neptune Ducati
19	Timers	:	Schneider Electric / Siemens
20	Relays (Numeric-type)	:	Alstom/ Schneider
21	Relays (Electromagnetic-type)	:	Areva / Easun Reyrolle
22	Cast Resin CTs / Cast Resin PT's / Control Transformers in Panels for metering & protection	:	AE / Gilberts & Maxwell
23	Soft Starter	:	Schneider Electric / Siemens
24	PLC		Allen Bradley / Siemens
25	FRLS PVC / MS / GI Conduits & Accessories	:	BEC / RM Con
26	Wires - Copper Armoured / Unarmoured	:	Bonton / Rajnigandha
27	Cables (Power & Control) - Aluminum / Copper Armoured / Unarmoured		Gloster / AVOCAB
28	Fire Survival Cable	:	AFW / India Impex (FR-Tek)
29	Cable lugs & thimbles	:	Dowells / Jainson
30	Cable glands	:	Comet / HMI / Lotus
31	GI / MS Raceways / Cable Trays	:	KM Enterprises, Faridabad / Profab
32	Modular Hanging / Supporting system for cable trays, rising mains & bus ducting (Channel, Threaded Roads & Clamps)	:	HIRA WALRAVEN / MUPRO
33	Wire Mesh Cable Tray	:	Legrand - Cablofil / Gewiss - OBO
34	VFD	:	Danfoss / Schneider
35	Active Harmonic Filter	:	Neptune-Ducati / Schneider Electric

36	Detuned Filters		Neptune-Ducati / Schneider Electric
37	Capacitors : Heavy duty type (MPPH type) / Inert gas type	:	Schneider Electric / Ducati-Neptune
38	APFCR (Automatic power factor correction relay) Micro Processor Based (BMS / Non BMS Compatible) 3 Phase type	:	Schneider Electric / Ducati-Neptune
39	Surge Suppressor Device	:	ASCO / Vitzrotech
40	ATS		ASCO (Imported) / Vitzrotech
41	Panels	:	Tricolite / Adlec
42	TTA Panels	:	Schneider - Blocket / Rittal
43	Panel Construction materials :		
a.	Electrolytic grade Aluminium bus bars	:	Hindalco / Century / Jindal
b.	Electrolytic grade Copper bus bars	:	Leebo Metal / Century
c.	Heat Shrinkable Sleeves	:	Pla Tech
44	Hardware		
a.	High Tensile Alloy Hardware for Panels / Distribution boards / earthing tapes (Zinc coated) (Grade 8.8 & Grade 5.6)	:	Unbreako / TVS
b.	Stanless Steel Hardware for Panels, boards & earthing tapes (SS-304, SS-316)	:	Duplex Fastners (Ramesh Steel Corporation, Gujarat) / Red Earth Steels, Mumbai
c.	Moulded Bus Bar Supports SMC/Nylon 6.6	:	Power Mat / Ramanuj
d.	Panel Cooling Ventilation Fans	:	High Cool / Rexnord
e.	Thermostat/Humidistat for Panel	:	Honeywell
f.	Panel Space Heater	:	Telelec
g.	GI Earth Tapes Exothermic Welding (UL Listed Only)	:	Erico-CADWELD / Dehn
h.	GI & Copper Earth Tapes Cross & Straight Connectors (GI, Copper & SS connectors)	:	Dehn / OBO

D.	**FOR CPO / CPM ITEMS**		
1	Standalone 32 bit DDCs		NETIX.AI/ ENLITE
2	Web Based BMS Software with unlimited user license		NETIX.AI/ ENLITE
3	Web Based Router / Network Area Controller		NETIX.AI/ ENLITE
4	Immersion Temperature Sensor		Dwyer / NETIX.AI
5	Duct Temperature Sensor		Dwyer / NETIX.AI
6	Outside Air Temperature Sensor		Dwyer / NETIX.AI
7	Room Temperature Sensor		Dwyer / NETIX.AI
8	Duct Humidity Sensor		Dwyer / NETIX.AI
9	Room Humidity Sensor		Dwyer / NETIX.AI
10	Flow Meter		Virtec / Axioma
11	Duct Static Pressure Sensor		Dwyer / NETIX.AI
12	Water Level Switch		Dwyer / NETIX.AI
13	DP Switch – Water		Dwyer / NETIX.AI
14	DP Switch – Air		Dwyer / NETIX.AI
15	CO2 Sensor		Dwyer / NETIX.AI
16	Water Flow Switch		Dwyer / NETIX.AI
17	Pressure Transmitter – Water		Dwyer / NETIX.AI
18	Current Relay		Veris / Seto
19	Voltage / Current / Power Factor Transducer		SETO / ABB
20	Flame Proof Level Switch / Level Transmitter		Veksler / Filpro
21	PH Sensor / TDS Sensor		Dwyer / NETIX.AI
22	Personal Computer		HP / DELL
23	Colour Monitor		HP(PAVILION) / SAMSUNG(SYNC MASTER)
24	Printer		HP / EPSON

25	Copper Conductor Control Cable		RALLISON / BONTON
26	Communication Cables / Signal Cable		RALLISON / BONTON
27	LAN cables for BMS Network		BELDEN / LEGRAND
28	PVC Conduits		RMCON / AKG
29	UPS		VERTIV / EATON
30	GI / MS Cable trays		ASAWA / KME
31	Battery (sealed maintenance free)		Panasonic / Global Yuasa

SECTION: 9

COMPLIANCE UNDER EIA

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COMPLIANCE UNDER EIA

Contractor to comply with the provisions under EIA, but not limited to following provisions:

1. Contractor would not be permitted to store/dump construction material or debris on metalled road.
2. Beyond the metalled road the area where such the construction material or debris can be stored shall be physically demarcated by 'the Contractor ensuring that it would not cause any obstruction to the free flow of traffic/inconvenience to the pedestrians. It should be ensured that no accidents occur on account of such permissible storage.
3. Contractor shall ensure that the construction material is covered by tarpaulin and all other precaution should be taken to ensure that no dust particles are permitted to pollute air quality as a result of such storage.
   It shall also be ensured that appropriate protection measures are taken by raising wind breakers of appropriate height on all sides of the plot/area using plastic and for other similar material to ensure that no construction material dust fly outside the plot area and it will be the builder/contractor responsibility to ensure that their activity does not cause any air pollution during course of construction and/or storage of material or construction activity. This condition shall be strictly adhered to by every builder, contractor, person or authority. In the event of default they shall be liable to be prosecuted under the law in force, as well as for causing environmental pollution and will be liable to pay compensation which would be determined by Tribunal in accordance with law.
4. All the trucks or vehicles of any kind which are used for construction purposes/or are carrying construction material like cement, sand and other allied material should be fully covered. The vehicles should be properly cleaned, should be dust free and every necessary precautions is to be taken to ensure that enroute their destination, the dust, sand or any other particles are not permitted to be released in air/contaminate air. Any truck not complying with the above directions would not be permitted to enter the area.
   And whereas Hon'ble National Green Tribunal in order dated 10.04.2015 interalia directed as follows:
   a. Contractor shall put tarpaulin on scaffolding around the area of construction and the building. No person including builder, owner can be permitted to store any construction material, particularly sand on any part ofthe street, roads in any colony.
   b. The construction material of any kind that is stored in the site will be fully covered in all respects so that it does not disperse in the Air in any form.
   c. All the construction material and debris shall be carried in the trucks or other vehicles which are fully covered and protected so as to ensure that the construction debris or the construction material does not get dispersed into the air or atmosphere, in any form whatsoever.
   d. The dust emissions from the construction site should be completely controlled and all precautions taken inthat behalf.
   e. The vehicles carrying construction material and construction debris of any kind should be cleaned before it is permitted to ply on the road after unloading of such material.
   f. Every worker working on the construction site and involved in loading, unloading and carriage of construction material and construction debris shall be provided with mask to prevent inhalation of dust particles.
   g. Every owner and or builder shall be under obligation to provide all medical help, investigation and treatment to the workers involved in the construction of building and carry of construction material and debris relatable to dust emission.
   h. It shall be the responsibility of every builder to transport construction material and debris waste to construction site, dumping site or any other place in accordance with rules and in terms of this order.
   i. All to take appropriate measures and to ensure that the terms and conditions of the earlier order and these orders should strictly comply with by fixing sprinklers, creations of green air barriers.
   j. Compulsory use of wet jet in grinding and stone cutting.
   k. Wind breaking walls around construction site.

l. All the builders who are building commercial, residential complexes which are covered under the EIA Notification of 2006 shall provide green belt around the building that they construct. All Authorities shall ensure that such green belts are in existence prior to issuance of occupancy certificate.

m. All builders shall ensure that C&D waste is transported in terms of this order to the C & D Waste site only and due record in that behalf shall be maintained by the builders, transporters and NCR of Delhi.

n. Even if constructions have been started after seeking Environmental Clearance under the EIA notification 2006 and after taking other travel but is being carried out without taking the preventive and protective environmental steps as stated in this order and MoEF guidelines, 2010, the State Government, SPCB and any officer of any department as afore stated shall be entitled to direct stoppage of work.

And whereas, Environmental Impact Assessment Guidance Manual for Building, Construction, Township and area Development Projects of February, 2010 is available on the website of MoEF &CC envisaging the following guidelines for mitigation measures in respect of dust control from Building, Construction projects:

"*Adopting techniques like, air extraction equipment, and covering scaffolding, hosing down road surfaces and cleaning of vehicles can reduce dust and vapour emissions. Measures include appropriate containment around bulk storage tanks and materials stores to prevent spillages entering watercourses.*

The other measures to reduce the air pollution on site are:

- *Sprinkling of water and fine spray from nozzles to suppress the dust.*
- *On-Road- Inspection should be done for black smoke generating machinery.*
- *Promotion of use of cleaner fuel should be done.*
- *All DG sets should comply emission norms notified by MoEF.*
- *Vehicles having pollution under control certificate may be allowed to ply.*
- *Use of covering sheet to prevent dust dispersion at buildings and infrastructure sites, which are being constructed.*
- *Use of covering sheets should be done for trucks to prevent dust dispersion from the trucks, implemented by district offices.*
- *Paving is a more permanent solution to dust control, suitable for longer duration projects. High cost is the major drawback to paving.*
- *Reducing the speed of a vehicle to 20 kmph can reduce emissions by a large extent.*

Speed bumps are commonly used to ensure speed reduction. In cases where speed reduction can't effectively reduce fugitive duct, it may be necessary to divert traffic to nearby paved area.

Material storages – care should be taken to keep all material storages adequately covered contained so that they are not exposed to situation where winds on site could lead to dust / particulate emissions. Fabric and plastics for covering piles of soil and debris is an effective means to reduce fugitive dust.

SECTION: 10

HSE GUIDELINES

SAFETY

This document sets out **GU** expectations from contractors on Environment, Health and Safety aspect of the construction workers deployed at the project site. It provides general EHS procedures for most, but not all, construction activities to prevent accidents and to monitor/correct violations of procedures through regular Safety meetings. However, a key requirement for EHS success is serious commitment from senior management and strong safety leadership at the project site with well-defined roles and responsibilities of the assigned individuals. Towards that, it is imperative that the selected Managing Contractor employs a well-qualified (relevant qualifications) and experienced Safety Officer responsible for implementing and continuously communicating and driving the procedures throughout the labour force. Being one of the key critical to quality (CTQ's) parameters, the contractors shall be required to submit with their tenders their organization safety policy, risk assessment along with brief summary of the safety performance on projects that they have managed in the last three years (i.e. number of man-hours, number of fatalities, accidents, near misses, type and cause of accidents, etc).

Scope of procedures and relationship with GU:

The Contractor's Safety & Health Procedures applies to all contractor and its subcontractor employees and to all construction and maintenance activities on the job site. A close relationship and continuous interaction must be maintained with **GU** Project team by the construction manager of the contractor. **GU** does have specific safety and health requirements as perthe **GU**'s EHS policy to be observed and cooperation with its representative, Architects, consultant various audit teams and other contractors at site, throughout the contract period is essential.

Selection of sub-contractor:

The main contractor shall select sub or works contractors, using the same criteria of practical safety policy. Again, it must be ensured that the terms of contract include adequate provision for safe working practices & for specified safety and health items.

Standards

The prime contractor and all subcontractors are to comply with the Client specific rules and procedures, the national legislation and codes and in particular the following standards;

IS: 3696 (Part I) -1966 Safety code for scaffolds and ladders: Part I Scaffolds IS:
3696 (Part II)-1966 Safety code for scaffolds and ladders: Part II Ladders IS: 3764-
1966 Safety code for excavation work

IS: 4082-1977 Recommendations on stacking and storage of construction materials at site (first revision)IS:
4130-1976 Safety code for demolition of building (first revision)

IS: 4912-1978 Safety requirements for floor and wall openings, railings and toe boards (first revision)IS:
5121-1969 Safety code for piling and other deep foundations

IS: 5916-1970 Safety code constructions involving use of hot bituminous materialsIS:
7205-1974 Safety code for erection of structural steel work

IS: 7969-1975 Safety code for handling and storage of building materialsIS:
8989-1978 Safety code for erection of concrete framed structures

IS: 7293-1974 Safety code for working with construction machineryIS:
10291-1982 Code of dress in Civil Engineering works, safety

IS: 875-1964 Code of practice for structural safety of buildings and loading standardsIS:
1905-1980 Code of practice for structural safety of buildings, masonry walls

IS: 10386-1983 General aspects Part 1 – 1983, Part 2 – 1982, Part 6 – 1983, Part 10 – 1983 Amenities, protective clothing and equipment, construction, storage, handling, detection and safety measures for gases, chemicals and flammable liquids IS: 2925-1984 Safety helmet tests

IS: 5983-1980 Testing for Eye protectorsIS:
7524 (Part I)-1979 Safety goggles

IS: 1179-1967 Welding helmetsIS:
5914-1970 Safety shoes

IS: 4770-1991 Safety gloves

IS: 12254-1993 Rubber/ PVC knee boots/ gum boots

Client specific requirements for compliance with OSHA standards

SECTION 2: ELEMENTS OF CONSTRUCTION SAFETY

Planning:

Detailed planning should take the following matters in to account;

- Obtaining work specific permits like;
- Permit for work at Height
- Hot work permit
- Disposal permit
- Excavation permit
- Night work permit
- Permit for working in restricted areas
- Confined space Entry permit
- Shaft work permit

- Know the hazardous operations eg. Use of cranes and site transport, structural erection, excavation and false work, scaffolding, roof work, demolition etc.
- Requirement for plant and equipment to ensure safe working or ease of handling
- Sequence of work and its phasing between contractors to minimize the possibility of one contractor placing another contractor's men at risk, where appropriate the segregation of contractors should be considered
- Need to provide information, instruction and appropriate training, both on general site safety and hazardous specific in the site. The latter could range from restricted zones, Permit-to-work systems, lifting operation to the wearing of Personal protective equipment
- Need for fire precautions and emergency procedures
- Need for environmental monitoring and health surveillance
- Site security and foreseeable risks to the public, including the need for directional and warning signs
- Safe access across the site for persons, vehicles and equipment. Thought should be given to arrangements for keepingthe site tidy, accommodation for site staff, safety welfare, first aid and other facilities
- Provision of safe places of work at different stages of the job including the provision of scaffolding, ladders for a numberof sub-contractors.

Control:

Sub and works contractors shall be briefed about the safety policy and site including site specific safety procedures of the prime contractor at the pre-bid meeting itself and further reiterated during the kick-off meeting. Responsibilities of all parties shall be clearly defined before contractors start work at site. Such matters should include:

- Appropriate precautions and methods for identified hazards or hazardous work
- Necessary plant, equipment and arrangements for its provision, maintenance use and inspection
- Question of trade union or other workforce safety representation and the need for a joint safety committee
- A formal joint safety committee must be appointed to review results and to initiate further actions (should be done eitherduring kick-off meeting or subsequently)
- Arrangement for initiation of introduction training for new states on site
- Arrangements for any specialized training
- Arrangements for promulgating safety and health information e.g. On-site notice boards

It is important that such safety and health arrangements are reviewed at the Kick-off meeting as well as first project and first Safety meeting, where the site management can set the tone for the conduct of work by resolving at an early stage the difficulties which may arise at a later date. It is expected that each subcontractor will provide employees adequately licensed(if required for specific works), trained and capable of doing the specialty work.

Coordination:

The Site In-charge appointed by the prime contractor shall be totally responsible for compliance with this health and safety code. The contractor must appoint a Chief Safety Officer and form a "contractor safety committee" along with safety representatives from its sub-contractors. This committee will be chaired by the Site In-charge and meet at least once a weekto review status on EHS issues. It is expected that each contractor and sub-contractor will participate in Daily "Tool BoxTalks" and other safety meeting to co-ordinate project work for the day across trades. The site in-charge must make suitable arrangements to ensure the effective coordination of the work of all its sub-contractors on site. Clear lines of communication should be set up between each sub-contractor's Safety Officer and Safety officer of the prime Contractor. Effective co-ordination will be enhanced by ensuring that 'Safety and Health' figures prominently on the agenda of regular project meetings, as well as Safety meetings. For better coordination on project related EHS issues, the safety meeting participants shall include Project Manager, Project Manager's Safety representative, all contractor's safety representatives along with 's safety rep. Project Manager's Safety officer shall convene this meeting and participants from all contractors safety representatives will be mandatory. Minutes of this meeting shall be circulated to all concerned.

Monitoring:

Arrangements must be made for safety and health monitoring of the site on a regular basis. This will include, not only ensuring the safety issues associated with working at heights, excavations, working with energy sources, etc. but also environmental matters such as hazardous dust, fumes, noise etc. In all cases, the contractor's Site- In-charge shall ensure that daily site inspections are carried out by the contractor's Safety Officer, more in depth inspection being done periodically

by visiting safety advisor. It may be necessary for arrangements to be made for specialist occupational health and hygiene advice. The checklist for daily inspection is provided which must be included in the Behaviour Observation Process (BOP).

Records:

The prime contractor should ensure that all statutory notification, examinations and inspections are carried out. Except for equipment used exclusively by individual contractors, all records should be kept & updated by the contractor's Site In-charge. This individual shall also keep track of all Safety statistics and send report to **GU** Project team on periodic basis, as determined by **GU** Project Manager.

Non-Compliance with Safety and Health Provisions:

The compliance with Environmental Health and Safety provisions is of utmost importance to the. The contractors must note that the will take a serious view of any Safety non-compliance notices. The has a right to order stoppage of work till rectification is carried out to the satisfaction of the safety committee or safe arrangements are made for the execution of work and all stoppages on this account will be at the entire risk, costs and consequences of the contractor.

Disciplinary action:

Noncompliance of the Safety and Health Provisions will result in disciplinary action as per the procedure below:1st time violation: Written warning

2nd time violation: Imposition of penalty as deemed fit by **GU** Project Manager3rd time violation: Removal from site

In the event of the offender bringing itself or others in direct life-threatening situation or where he/she creates a large material damage, will result in immediate removal from site. Repeated violations by a contracting company shall lead to termination of contract and removal of contracting firm from the job site. Any losses incurred by the contracting company, whatsoever, shall be the responsibility of contracting company.

Imposition of penalties for non-compliance with EHS guidelines:

The contractor will be required to comply with all the requirements laid down in these EHS guidelines, Special safety conditions, General conditions of contract and any other safety requirements as a matter of general prudence. Upon failure to comply with any of these, Project Manager is authorized to impose penalty on the contractor as per the details below:

Schedule of Charges to Contractors who are in breach of the employer's Site Safety, Site Safety Cycle and Environmental Rules and Regulations:		
S No.	**Nature of Offence**	**Amount of Safety or Environmental Charge to be levied against the Sub Contractor for each breach of the employer's Rules & Regulations (Indian Rs)**
1	Smoking in an unauthorized area and/or consumption ofalcohol and/or use of illegal substances.	Rs 1000.00
2	Burning of waste or smoldering of combustible materials on site other than for heat treatment processes required for the execution of the Sub Contract works.	Rs 3000.00
3	Failure to wear personal protective equipment (P.P.E.) e.g. Safety helmets, safety boots, goggles etc. respirator, ear plugs, safety belts which shall include failure to anchor belt to a secure structure.	1) Rs.1000.00 per worker when lack of enforcement of the usage of P.P.E. by the Contractor/ Sub-contractor is observed by the employer.
	Where any site operation requires the use of PPE then all workmen must use the required PPE eg. grinding, welding, burning, unloading hazardous materials etc.	2) Rs. 2,000.00 where issuance of the required P.P.E. by the Sub Contractor equipment is not carried out.
4	Failure to attend general safety induction courseconducted by the employer / the employer.	1) Rs.5000.00 per worker for not attending the course; and
		2) Workers to attend course within 2 working days orbe dismissed.

5	Failure to attend a notified site safety meeting.	Rs 5,000.00
6	Failure to submit, within the specified time to the employer, safety supervisor reports which shall include other relevant statutory reports made under the F&IUO Cap. 59, tool box briefing records, weekly Labour return, issuance of personal protective equipment records, safety data sheets of toxic and harmful materials and others related certificates.	Rs 5,000.00
7	Failure to submit a written report for an accident and/or other dangerous occurrence, to the employer within 24 hours of its occurrence.	Rs 5,000.00
8	Failure to carry out within the specified time thenecessary improvement action against any notified safety violation.	Rs 8,000.00
9	Damaged to or misuse of the employer's property.	1) Rs. 5,000.00; and 2) in addition the Sub Contractor to pay for the cost of items damaged.
10	Failure to maintain work area, facility storage and preparation yard, office premises and workers changing and rest area in a clean and orderly state and free from health and fire hazards.	1) Rs 3,000.00; And 2)in addition the Sub Contractor shall clean up thedisorderly and untidy areas within 3 days.
11	Obstruction of passageways, entrance, door, way's, stairs, access to firefighting equipment etc. and /or theerection unsafe access and crossing's	Rs 5,000.00 In addition sub-contractor shall clean up the disorderly and untidy areas within 1 day.
12	Use of equipment that has not been examined by an approved person as required under the factories and industries undertaking ordinance and its related regulations.	Rs 7,000.00
13	Use of defective or uncertified sling's for liftingoperations	Rs. 8,000.00;
14	Executing unsafe hoisting of materials and include unsafe use of lifting appliance.	Rs 10,000.00
15	Erecting and / or using unsafe or unstable scaffolding,working platforms and temporary structures.	Rs 7,000.00
16	Failure to provide and use proper working platforms and safe means of access to the work place, where work is required to be carried out beyond person's normal reach.	Rs 10,000.00
17	Allowing workers to occupy or work on unguarded elevated platforms, floor edges and without adopting adequate safety measures against the risk of person falling from height.	Rs.7,000.00; .

18	Not providing safety barricades / barriers to hazardous floor edge, openings, gaps and shafts.	Rs.7,000.00;
19	Rendering scaffold or working platform unsafe bytampering / alternation.	Rs.10,000.00;
20	Placing of heavy items unsafely on scaffold orworking platforms.	Rs 5,000.00
21	Throwing or allowing objects to drop from heights.	Rs.10,000.00
22	Stacking or leaving materials include work in progress articles and tools in unstable condition and or along flooredges such they are likely to endanger workers.	Rs 8,000.00;
23	Failure to effectively cordon off guard and warn other workers from entering into the danger areas when they are likely to be affected by falling materials from the sub-contractor work.	Rs 8,000.00
24	Violating the permit to work system	Rs 10,000.00
25	Dismantling and rendering any safety guards or protective features of any part of a machine or any partof building structure to extend that such guards and protective features are not operational or are incapable of providing the necessary protection for its design and purpose.	Rs. 10,000.00 .
26	Adopting unsafe tapping, connections and termination of electrical lines and including the use of defective electrical fittings, power cables and electrical tools. Allowing cables / equipment to be merged into water.	Rs 5000.00;
27	Using any defective or unsafe equipment.	Rs 5,000.00
28	Unauthorized use of fire equipment provided foremergency purposes.	Rs.5,000.00
29	Failure to comply with an order issued by the employer's construction manager, safety officer in regard tosafety/environment matters.	Rs.8,000.00
30	Threatening safety personal, misbehaver, fighting orintentional causing hurt to others.	Rs.10,000.00 Person to be banned from the site and report will be made to the police.
31	Failure to wear safety harness and anchor to a secure structure, while working at height.	Rs 5,000.00 if there is 2nd time violation by the sameperson or group attract penalty Rs. 10,000 or more
32	Failure to provide valid certificates for lifting appliances and accessories including any lifting appliance / accessories on vehicles delivering goods to the site.	Rs.8,000.00
33	Failure to provide voltage reducing device onwelding machine.	Rs 4,000.00;
34	Failure to attend site safety walk	Rs 5,000.00

35	Deploying under age or over age worker worker or staff	Rs. 10, 000.00
36	Pregnant women to be not engaged at the constructionsite	Rs. 10, 000.00
37	Failure to provide site safety officer as per the requirement of latest ordinance.	Rs 10,000.00

Note:-

Procedure of Debit:-

- A debit Note will be issued to vendors with the backup records of Non-Conformity and the Penalty amount will bedebited from the Running Bill.

- Prior to the above a 'non conformity notice' shall be issued to give last opportunity to the vendor to comply therequirements.

- Please ensure that all OHSE NON –Conformities with debits are in the notice of client with acceptance beforetaking forward to the contactors.

SECTION 3: SAFETY AUDITS

1) It is essential to conduct formal periodic safety audits to prevent deviations from safety standards.
2) The audit should take the form of a full survey covering all aspects of safety throughout the project site. Reports should be submitted to the Safety Committee. Copies of the results of a survey should be sent to the persons in charge of the respective areas so that corrective measures can be taken. A copy of the Audit report should also be sent to the ProjectHead.
3) Audit team should cover the following aspects:

- Organization
- Accident control
- Hygiene facilities
- Electrical systems
- Fire prevention
- Demarcated areas
- Mechanical equipment
- Safe work practices
- Storage areas
- Material stacking
- Housekeeping
- Safety statistics
- Display of emergency numbers
- MSDS sheets
- Personal Protective Equipment
- Safety training
- Safety meetings
- First aid facilities
- Traffic control, Signage, etc.

4) Findings of the safety audits shall be sent to Safety committee and also be discussed in the Safety committee meetings.
5) Work place audits should also be carried out at job site frequently (at least every week) conducted by representatives of respective contractors to make sure that all Safety provisions are getting complied with. These should primarily focus on Safe working systems, Housekeeping, Machine guarding and use of PPE. Results of these audits shall be reported to the Safety committee.

SECTION 4: ACCIDENT PREVENTION, REPORTING AND INVESTIGATION

Definition:

An accident is commonly defined as: "An unplanned event which may or may not result in injury or damage". As is clear from the definition, an accident need not necessarily involve either injury or damage to person or property. A "near miss" is by definition an accident and should be regarded as a warning that a problem exists and that some action is required to avoid a possible accident/ incident in future.

Causes of Accidents:

88% of all accidents are caused by human error, 10% are caused by mechanical failures and the other 2% are considered outside human control eg. Earthquake etc. The likely causes of accidents should be identified in advance and the appropriate action taken to ensure that the accident never actually takes place. The most important and effective accident prevention technique is training the actions and attitudes of all personnel.

Accident Recording and Investigation

It is essential to have an effective management system for recording accidents. All accidents should be thoroughly investigated. A near miss or incident should be investigated as though an accident had occurred. The prime objective of all investigations of this type is to identify the causes in order to eliminate the risk. Such aspects as systems training and guarding should all be considered in addition to what actually happened and why. The accidents record should include accidents to employees and non employees on company premises i.e. Contractors, construction workers, maintenance workers, visitors etc. and to those using company vehicles. Supervisory staff and, when possible, department personnel should be involved in any investigation relating to their area of control and should be delegated in writing to conduct a detailed analysis of the causes. They should determine how best to prevent a recurrence and this should be taken into account in the report. The depth of the investigation and the effectiveness of the follow up action should be monitored. Records of all accidents must be kept to enable statistics to be analyzed and root causes determined.

Incident Control System

Unsafe acts & conditions and "near misses", if they are not dealt with appropriately, can turn into accidents. It is essential that companies operate an incident control system to ensure that these potential hazards are reported and eliminated. The system should;

- Ensure that whenever possible safety representatives and other employees are involved
- Encourage any person to register an unsafe action or conditions
- Ensure that reports are recorded and acted upon
- Identify the responsibility for investigation and for carrying out corrective action
- Specify the time within which the corrective action should be completed or progress reported
- Ensure that a report is made to management and to the originator when
- corrective action has been completed

Levels of Accident Investigation:

The type or level of accident investigation depends on the nature and seriousness of the incident. In most cases, an "Accident and Incident investigation panel will be formed which will determine the appropriate level of investigation.

Types of Investigation:

• A full investigation which requires a panel including a Project Manager, Safety Officer and Contractor's Safetyrepresentative and GU Corporation Pvt Ltd project team representative or a panel as determined by Project Manager.

• A departmental investigation involving the departmental manager(s) the safety officers and the appropriate supervisor

• An investigation by the supervisor involving, where appropriate, the employees concerned

Lost Time Accidents (LTA):

This refers to the total number of accidents of all types which result in lost man hours. Lost man hours occur if the person involved is unable to return to normal duties immediately after any treatment.

Reportable Accidents:

When an employee, as a result of a lost time accident, is absent from work for more than two days (48 hour), then this will be recorded not only as a lost time accident but also a reportable accident. Brief details of each reportable accident and the steps taken to avoid repetition should be given in the Project Mangers monthly Report.

Serious Accident:

This is an accident which causes death or serious injury e.g. a broken limb, amputation serious burns etc., or hospitalization for one or more nights. In addition any escape of gases/toxics substances, which affect the environment and the surrounding area / community even if it does not cause injury to people, is considered a serious accident. This definition applies to employees and non employees, the yardstick that defines whether it is a serious accident in site terms is whether the victim was on company premises on company business, or using company equipment or transport. Thus if an operating companyis in any way involved in a serious accident then it must be fully investigated and reported to company management.

Incident / Near Miss:

This can be described as an undesired event which, under slightly different circumstances, could have resulted in an accident.

Reporting Accidents/ Incidents/ Near Misses:

All Accidents/ Near misses must be reported to Project managers of the company immediately, with brief details. A preliminary report will then be submitted by the Project Manager to the Zonal Associate Director and Executive Director, as per the procedure outlined in Project Management firm's Standard Operating Procedures. A full and final report will subsequently need to be prepared and submitted. The contractor shall submit the report in the standardized format attached with these EHS guidelines.

Reporting Accident Statistics:

Accident statistics reported to company should be based on employees at job site. Accidents to non-employees (vendors or sub-vendors) should be reported as separate statistics.

Statistical formulae:

Lost time Accidents: This is the total number of accidents including all reportable and serious accidents

Reportable Accident: This is the number of accidents where an employee is absent from work for more than 48 hours consecutively (excluding the day of accident).

Percentage man hours lost: This is the total number of hours lost expressed as a percentage of total man hours worked.Total man hours lost X 100%

Total man hours worked

The lost time accidents, reportable accidents and percentage man hours lost should be reported on a monthly basis as part of the Project Manager's review. The figures given in each category should be for the month under review, the year to date and the previous year to date.

Accident Frequency rate:

This is the total number of lost time accidents per 1 million man hours worked by permanent and temporary employeesTotal number of lost time accidents X 1,000,000

Total number of man hours worked

Accident incident rate:

This is the total number of any accidents per 1000 employees.Total number of lost time accident X 1000

Average number of persons employed

For this calculation the total number of employees should be averaged out over the year. Part time employees should be included in proportion to the time worked. The accident frequency rate and accident incidence rate should be calculated annually and reported in the year end results. In addition to the statistics referred to above, all data pertaining to incidents must also be kept at site.

SECTION 5: MANAGEMENT RESPONSIBILITY FOR SAFETY

Management has the responsibility to ensure that a well developed Safety program is in place. The contractors are obligated to provide;

- Safe place of work, which includes safe means of access and exit during normal daily work routine as well as in emergencies
- Safe plant and equipment including the maintenance of it
- Safe systems of work. This includes safe working practices and work instructions for all jobs taking particular account of hazardous situations
- Safe working environment and proper arrangements for employee welfare. This responsibility includes proper lighting, ventilation, fume and dust extraction, noise control, housekeeping, seating, drinking water, sanitary facilities and a wide range of other factors
- Safe methods for storing, handling and transporting goods and substances
- Such information instruction, training and supervision as are necessary to ensure efficient and safe workingpractices, which comply with national legislation and company rules.
- Basic and job related safety training for all its and as well its Sub contractor's
- Temporary and permanent employees.
- Consultation with employee with a view to making and maintaining adequate and effective arrangements for health safety and welfare
- A written statement with respect to the health, safety and welfare of the employees containing details of procedures which will put the policy into effect and define individual responsibilities for safety
- Where accommodation provided in the GU CORPORATION PVT LTD premises, this must conform to the same safety and hygiene standards as other company premises, in respect of the premises itself and the working of any staff.
- Safe and correct work procedures must be followed for carrying out any construction activity.

SECTION 6: SAFETY ORGANISATION

The contractor/ contracting company shall appoint in writing a person to direct and co-ordinate job site safety program. This person should be a full time, technically qualified safety officer and must have received formal training in Health and Safety.In addition, the contracting company shall also appoint required number of safety stewards, as per prevailing Laws and regulations, but in any event, a Safety steward shall be on the job site at all times when work is ongoing. The duties and responsibilities of contractor's safety manager should be clearly defined at the outset, which will include managing the company health and safety program in order to achieve an accident free environment.

Duties of contractor's Safety Manager

The precise duties of the manager responsible for health and safety will be determined by the contractor/ contracting company concerned and the following should only be taken as a minimum guideline. In general the duties shall include:

- To manage the company Health and Safety program

- To make recommendations on matters concerning health and safety to the Director responsible for the company health and safety program in order to achieve the company's health and safety objectives To inspect all or part of the premises daily to ensure the program is being complied with To carry out full inspection at least once everyweek for potential hazards To prepare Pre task plans and make necessary modifications till they are accepted by Project Manager's Safety representative
- To recommend any necessary health and safety rules including changes where appropriate
- To arrange adequate materials and publicity for the Health and Safety Program
- To arrange, attend and supply relevant material for Safety Committee Meetings and weekly safety meetings
- To conduct appropriate job related health and safety training for all new and existing staff whether temporary orpermanent. Any job change should be accompanied by relevant retraining.
- To carry out specific health and safety training for managers, supervisors and safety representatives.
- To properly investigate all accidents, damage to property and near miss incidents and make sure that anycorrective action is implemented
- To maintain accident records and make a weekly inspection of first aid records and implement any necessarysubsequent action
- To prepare weekly summaries of injury/damage and inspection reports for senior management
- To ensure that all fire equipment is regularly inspected and serviced.
- To ensure the provision of safe tools, equipments and protective clothing where appropriate, and their safe use.

SECTION 7: SAFETY COMMITTEE

Formation of a site specific safety committee is one of the best methods of obtaining employee involvement in safety. The committee should have formal status and its members shall include;

- Project Manager's Safety representative
- GU's Safety representative
- Contractor's safety representative
- Subcontractor's safety representatives
- Head – Site security
- Fire officer
- Any other members the management may decide to include

Objectives of Safety Committees:

The prime objective of a safety committee is to promote co-operation between employers and employees in order to investigate, develop and carry out measures designed to ensure the health and safety at work of the company's employees, non employees and other project participants on job site.

Functions of Safety Committees:

The key functions of Safety Committee shall include;

- To study the accident statistics and trends within their area
- To report on unsafe or unhealthy conditions together with recommendations which can then be made tomanagement and the safety group
- Examining safety audits relating to their area
- Considering reports comments and suggestions of safety representatives
- Giving assistance in the development of safety rules/ systems of work
- Commenting on the effectiveness of the safety content of staff training program
- Commenting on the adequacy of health and safety
- Communications in the workplace including on-the-job safety meetings
- Co-operating with management in carrying out regular safety inspection of departmental areas and reporting theresults of these inspections to the main safety committee.
- Organize safety training and demonstrations etc to make to make everyone aware about the safety procedures.
- Organize safety competitions for motivating people at site

The safety committees can only assist Management in taking decisions; they cannot substitute for Management. Management must still take overall responsibility for executive action with a view to ensuring that health and safety arrangements are checked regularly and that the health and safety policy as a whole is being implemented properly.

SECTION 8: CONTACTOR'S SAFETY INSPECTION CHECK LIST

Contractor Contract No. /Purchase order no ----------

Project----------

Location----------

Type of Work----------

Date Checked By----------

S	ITEM	STATUS	REMARKS
	Accident prevention Organization Trained First Aid person First Aid Kit Safety Material Posted Emergency Phone # Posted		
	Housekeeping & Sanitation General neatness of working areas Daily disposal of waste and trash Passageways and walkways clear Adequate lighting Projecting nails removed Oil and grease removed Waste containers provided & used Sanitary facilities adequate and clean Drinking water tested and approved Adequate supply of water Drinking cups, Clean Dispensers Exit sign posted		
	Fire Prevention Fire extinguishers identified, checked, charged Hydrants clear access to public thoroughfare Open Good Housekeeping		
	NO SMOKING posted and enforced where needed		
	Personal Protection Hard-hats Noise Level Exposure / Ear protection Eye Protection Safety Lines & harnesses Life Jackets (If necessary) Safety shoes / Gum Boots Gloves		
	Electrical Installation Adequate well insulated wiring Fuses & GFI provided Fire hazards checked Electrical dangers posted Open wires without adaptors not used Lock out / Tag out procedures used for maintenance of Electrical system, Temporary wiring not used as permanent installation. Personal protective equipment and clothing provided.		
	Gas Cutting Flash back arrester in all the gas cutting nozzles. Use of DA or industrial LPG only no domestic cylinders. Availability of fire extinguishers / water close by		
	Hand & Power Tools Tools and cords in good condition Proper grounding All mechanical safeguards in use Tools neatly stored when not in use Right tool being used for the job at hand Wiring properly installed Enough men used to handle material Use of GFCI for tools usedoutdoors		
	Ladders Stock ladders in good condition Stock ladders not spliced Properly secured, top and bottom Side rails on fixed ladders extend above top landing Built-up ladders constructed of sound materials Rungs not over 12 inches on center Stepladders fully open when in use Metal ladders not used around electrical hazards Proper maintenance and storage		

	Hoists, Cranes & Derricks Inspect cables and sheaves Check slings and chains, hooks and eyes Equipment firmly supported Outriggers used if needed Power lines inactivated, removed, or at safe distance Proper Loading for capacity at lifting radius All equipment properly lubricated and maintained Signalmen where needed Hoisting plan. Test certificate of all the lifting equipments. All equipments should display the last inspection date and the next due date		
	Motor Vehicles Brakes, lights, warning devices or barricaded Weight limits and load sizes controlled Personnel carried in safe manner. Seat belts provided and used. Reverse horn in working condition, PUC certificate available		
	Barricades Floor opening planked over or barricaded Roadways and sidewalks effectively protected Adequate lighting provided Traffic controlled		
	Handling & Storage of Materials Neat storage area, clear passageway Stacks on firm footings, not too high Men picking up		
S	**ITEM**	**STATUS**	**REMARKS**
	loads, correctly Materials protected from heat and moisture Protection against falling intohoppers and bins Dust protection observed		
	Excavation & Shoring Shoring of adjacent structures Shoring and sheathing as needed for soil and Depth Public roads and sidewalks supported and protected Materials not too close to the edge of excavation Lighting at night Water controlled Equipment at safe distance from edge		
	Concrete Construction Forms properly installed and braced Adequate shoring, plumbed and cross braced Shoring remains in place until strength is attained Proper curing period and procedures Check heating devices Adequate runways Protection from cement dust Hard-hats, safety shoes, shirts covering skin Nails and stripped form material removed from area		
	Masonry Proper scaffolding Masonry saws properly equipped, dust protection provided Safe hoistingequipment		
	Hoists, Cranes & Derricks Inspect cables and sheaves Check slings and chains, hooks and eyes Equipment firmly supported Outriggers used if needed Power lines inactivated, removed, or at safe distance Proper Loading for capacity at lifting radius All equipment properly lubricated and maintained Signalmen where needed Hoisting plan. Test certificate of all the lifting equipments. All equipments should display the last inspection date and the next due date		
	Motor Vehicles Brakes, lights, warning devices or barricaded Weight limits and load sizes controlled Personnel carried in safe manner. Seat belts provided and used. Reverse horn in working condition, PUC certificate available		
	Barricades Floor opening planked over or barricaded Roadways and sidewalks effectively protected Adequate lighting provided Traffic controlled		
	Handling & Storage of Materials Neat storage area, clear passageway Stacks on firm footings, not too high Men picking up loads, correctly Materials protected from heat and moisture Protection against falling intohoppers and bins Dust protection observed		

	Excavation & Shoring Shoring of adjacent structures Shoring and sheathing as needed for soil and Depth Public roads and sidewalks supported and protected Materials not too close to the edge of excavation Lighting at night Water controlled Equipment at safe distance from edge		
	Concrete Construction Forms properly installed and braced Adequate shoring, plumbed and cross braced Shoring remains in place until strength is attained Proper curing period and procedures Check heating devices Adequate runways Protection from cement dust Hard-hats, safety shoes, shirts covering skin Nails and stripped form material removed from area		
	Masonry Proper scaffolding Masonry saws properly equipped, dust protection provided Safe hoistingequipment		

SECTION 9: FIRST AID AND EMERGENCIES

Trained First Aid Person

A contractor shall provide, or ensure that required number of suitable persons as adequate and appropriate are provided inthe circumstances for rendering first aid to people deployed at site if they are injured or become ill at work. The trained first aid person should have undergone:

a) Such training and has qualifications as the Health and Safety Executive may approve for the time being in respect of that case or the class of case, and

b) Such additional training, if any, as may be appropriate in the circumstances of that case. In practice, (a) refers to a trained first aider and (b) to an occupational first aider. In addition, a person who holds a current first aid certificate issued by registered medical association or Indian Red Cross Society will be classed as a "Suitable Person" for the purposes of regulation. The contractors shall ensure that sufficient first aides are appointed to provide adequate coverage for each shift. Provisions for medical care must be made available by the contractor for every employee covered by the regulations. In the absence of dispensaries, clinics, or hospitals in proximity to the work site, properly trained and certified first aid personnel

must be available, and first aid supplies must be provided by the contractor. Appropriate equipment for transportation of injured personnel to a physician or hospital must be provided for. An emergency plan, medical care, firefighting and evacuation plan must be developed by the main contractor.

First Aid Kit:

Regardless of the number of people there must be at least one first-aid box on site. Every first aide and occupational first aider should have easy access to first-aid equipment, and provision should be made for every person to have reasonably rapid access to first aid. Each box should be placed in a clearly identified and readily accessible location, and contain a sufficient quantity of suitable first-aid materials and nothing else. Boxes and kits should be checked frequently to ensure they are fully stocked and all items are in a usable condition. Sufficient quantities of each item should always be available in every first aid box or cabinet.

S.No	Item	Numbers of People working at Site				
		1-5	6-10	11-50	100	150
1	Guidance card individually wrapped	1	1	1	1	1
2	Sterile adhesive dressings	10	20	40	40	40
3	Sterile eye pads with attachment	1	2	4	6	8
4	Triangular bandages	1	2	4	5	8
5	Sterile coverings for serious wounds	1	2	4	5	8
6	Safety pins	6	6	12	12	12
7	Medium sized sterile un-medicated	3	6	8	10	12
8	large sterile un-medicated dressings	1	2	4	6	8
9	X-large sterile un-medicated dressing	1	2	4	6	8
10	Sterile water in 300 ml disposable containers, where tap water unavailable	1	1	3	6	6

The first-aid box or cupboard should protect the content from dampness and dust and be clearly marked with a white cross on green background

First Aid Rooms:

Where there are 250 or more persons at work on site, a suitably staffed and equipped first-aid room should be provided. In addition, where there is a large (over 150) number of employees divided into several dispersed working groups, or the location of the site makes access to places of treatment outside difficult, the contractor should consider whether a centralized first-aid room may be needed. A First aid room should:

- Be under the charge of an occupational first aider in most circumstances: names and locations of all first aiders should be displayed
- Be readily available and used only for the rendering of first aid
- Be clearly identified and of sufficient size to allow access for a stretcher, wheelchair, etc. And hold a couch withspace for people to work around it
- Contain in addition to the previously mentioned first aid materials: a sink with hot and cold running water, drinking water, paper towels, impermeable work surfaces, clean garments for use by first aiders and occupational first aider's clinical thermometer a couch with pillow and blankets frequently cleaned
- Be heated, lighted, ventilated and cleaned regularly
- Be designed so that immediate contact can be made with the person on call, e.g radio, siren, and a telephone linkif feasible. It should be stressed that a sufficient number of first-aid boxes must be provided for any work area,which is not within easy reach of the first aid room.

Emergency Phone # Posted

Project name---------- **Project No. ----------**

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The following are the business telephone numbers where project key personnel can be reached at all times. In addition, the emergency telephone numbers of other vital agencies are listed:

BUSINESS RESIDENCE

Project Manager

GU Project Manager
Contractor Safety Officer
Fire/ Security officer

OTHER EMERGENCY TELEPHONE NUMBERS

Fire :

Ambulance :

Doctor :

Hospital :

Police :

Gas Company :

Electric Company :

Water Company :

Telephone Company :

Insurance Carrier :

SECTION 10: HOUSEKEEPING AND SANITATION

At the work site, an adequate supply of potable water must be provided, as well as clean drinking water dispensers. Potable water for clean up must be provided. Where non potable water is used for industrial or fire fighting purpose it must be identified by appropriate signs.

Apart from the above, the contractor has to adhere to general neatness of working areas, daily disposal of waste and trash, maintenance of clear passageways and walkways, providing adequate temporary lighting and ventilation (both natural as well as artificial) to perform the project related works, removal of projecting nails, removal of oil and grease, removal of loose unused construction material, provision for waste containers, and maintaining adequate sanitary facilities for the work force. The contractor and in turn its sub-contractors shall be responsible for cleaning behind them on daily basis. The accumulation of construction materials/ debris shall not be permitted at any location.

SECTION 11: FIRE PREVENTION

An emerging plan for firefighting and evacuation must be made. A training plan must be developed. Electrical wiring equipment for heating, light or power purposes must be installed in compliance with the statutory requirements. Internal combustion engine-powered equipment must be located with exhausts well away from combustible materials. Smoking is tobe prohibited in the vicinity of fire hazards, and such areas must be conspicuously posted. Care shall be taken properly to ground nozzles, hoses or steam lines used in hazardous tanks or vessels. In location of temporary buildings and yard storage, appropriate care shall be taken for proper separation to allow an accumulation of fire potential. The contractor is responsible for maintaining the entire construction area, but particularly storage areas, free from accumulation of unnecessary combustible materials. Sufficient fire extinguishers must be installed in all temporary buildings and storerooms. The contractor must identify and maintain proper escape routes at the project site in the event of a fire emergency. The escape routes should be sufficient in number and free from any encumbrances. All the workers as well as others working at job site should be made aware of them through training, mock drills and posting of exit signs. The contractor, consultation with the Project Manager must identify a “Mustering point” where all the workers would be required to gather in the event offire. The contractor must generate an “Evacuation Procedure” in the event of fire and post it at multiple locations on theproject site. The assembly area should be clearly defined and marked out. The procedure should include what should bedone to the ongoing activity when such a situation arises, which escape routes to follow, safe location to gather, who to call(with telephone numbers), how to inform the site security, etc.

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Site Fire Check List

- Are safe ashtrays provided where smoking is permitted? And are fire extinguishers installed?
- Are heaters properly guarded?
- Are wet clothes kept clear of heaters?
- Are portable heaters secure from being knocked over?
- Is all temporary wiring well supported and protected?
- Are any circuits overloaded?
- Are all flammable liquids, gas cylinders and flammable materials separately and properly stored?
- Are all gas appliances fitted with control taps?
- No burning of rubbish is permitted outside
- Is all flame cutting and welding taking place with proper precautions?
- Are all blow lamps and blow torches being used correctly and all the hoses protected?
- Do all night watchmen and security patrols know the fire routines?

Preventing the spread of fire:

- Is waste accumulating in hoist shafts, under belts, in odd corners?

- Are separate metal waste containers supplied for each of the following : oily rags, paint rags, paint scrapings,waste flammable liquids, wood shavings and offcuts?
- Is all waste regularly cleared?
- Are all huts safely located?

Means of escape:

- Are all gangways, stair and platforms free from obstruction?
- Does everyone know what to do in an emergency?
- Is fire drill practiced, and is there a system to ensure that all persons have
- evacuated the area?

Fire Fighting:

- Have all extinguishers been checked and / or recharged?
- Are they clearly identified and easily accessible?
- Are operatives trained in their use?

SECTION 12: PERSONNEL PROTECTION

The required personnel protective equipment (PPE) should be worn at all times. The contractor is encouraged to supply comfortable personnel protective equipment to the site workers. All necessary personnel safety equipment as considered adequate by the Engineer-in-charge shall be available for use of persons employed on the site and maintained in a condition suitable for immediate use, and the contractor shall take adequate steps to ensure proper use of equipment by those concerned. Irrespective of the type of work being performed, contractor will have 100% compliance with Safety hard hats, safety glasses and safety shoes. In addition for specific works described below though not limited to these only, additional safety precautions as stated will be taken by the contractor. Workers employed on mixing asphalt materials, cement and lime mortars/ concrete shall be provided with protective footwear and protective gloves. Those engaged in handling any material which is injurious to eyes shall be provided with protective goggles. Special protective goggles must be used by graining,sawing and drilling. Those engaged in welding works shall be provided with welder's protective eye-shields. Stone workers are employed in sewer and manholes, which are in use, the contractor shall ensure that manholes are ventilated at least foran hour before workers are allowed to get into them. Manholes so opened shall be cordoned off with suitable railing andprovided with warning signals or boards to prevent accident to public

During these activities in sewers and manholes, regular monitoring of oxygen levels and the presence of explosive mixtures and toxic gases are to be controlled. Suitable face masks shall be supplied for use by workers during painting work. Overalls shall be supplied by the contractor to workmen and adequate facilities shall be provided to enable working painters to wash during and on cessation of work. Special care should be taken with regards to the hygiene of the temporary facilities.

SECTION 13: ELECTRICAL INSTALLATION

The National Indian electric codes and regulations shall apply to all permanent and temporary electrical installations. A temporary power distribution system shall be installed in accordance with the national codes All other temporary connections and sub distribution systems shall be connected to this main system. All temporary power systems shall be properly grounded. Circuit breakers (incl. fuses) shall be used in all temporary power connections for system and cable protection. All wires shall be colour coded in accordance with the national codes. All electrical cables shall consist of solid copper conductors (stranded wires shall not be used). Only certified electricians will be allowed to enter high tension station, transformer and low voltage areas. All electrical installation work and all connections to the main power distribution system shall be done by qualified electricians from certified contractors. Usage of 30Ma ELCB as per IE guidelines (or as stated inits subsequent revisions)

SECTION 14: LADDERS

Work activities situated above 2.5m from ground floor level Precautions shall be made to avoid workers from falling down. For work above 2.5m from ground level, proper scaffolds need to be erected. No metal ladders to be used around electrical hazards. Special attention shall be paid to the material of the ladder for the type of work to be performed i.e. whether the ladder shall be metal or wooden.

Use of ladders and folding step ladders

This regulation applies to all ladders and pairs of steps but not roof ladders and crawling boards. Ladders must:

- Be fixed near the top if practicable, or near the bottom if not: if suspended they must be secure.
- Be placed (except when suspended) on a firm level base; they must not stand on loose packing (eg. Bricks)
- Be intermediately secured, where necessary, to prevent swaying and sagging
- Be supported, or suspended, equally on each stile.
- When working on a ladder above 2.5m, fall protection must be used.
- Extend at least 1.05m above any landing place beyond the highest rung from which a person may be working or have a nearby handhold of equivalent height.
- Be placed so that there is space behind each rung for proper foothold (eg. No rung should coincide with a scaffoldtube)

SECTION 15: SCAFFOLDING

Work activities above 2.5m from the ground level:

Precautions shall be made to avoid workers from falling down. For work above 2.5m above a floor level proper scaffolds need to be erected. Ladders properly secured can be used, but only for light work which can be done with one hand.

Supervision of work and inspection of material:

Scaffolds must be erected, altered or dismantled only under competent supervision and as far as possible, by experienced persons. All scaffolding materials must be inspected before use to check that they are up to standard. All inspected scaffolds must bear a sign “ready for use”.

Construction and material:

Sufficient sound material must be provided for a scaffold to be strong and stable enough for the job. Wherever timber is used for any kind of scaffolding purpose, it must be of the right type for the job and must not be painted so that any defects are hidden. Scaffold tubes and fittings must not be bent, distorted or unduly rusty.

Defective material:

Scaffold tubes, couples or fittings that are bent unduly rusty or distorted should be rejected. Timber with dangerous splits and knots should always be rejected. Ropes and lashings showing signs of chafing through wear, or of being corroded, should be rejected. All scaffold components must be properly stored when not in use and kept separately from all other building materials

Maintenance of scaffolds:

Scaffolding must be kept in good order and every effort made to prevent the accidental displacement of any part.

Partly erected or dismantled scaffolds:

If any scaffold is either partly erected (or partly dismantled), but nevertheless is still capable of being used to some extent, it must have a bold warning notice fixed, or all access blocked off or barred, at the point beyond which it cannot be safely used.

Standards or Uprights, Ledgers and Putlogs:

Scaffold standards should be vertical and spaced closely enough for the intended use of the scaffold. Base plates must be used. Timber sole plates should also be used to distribute the

load from the standard over a wide area, as well as to offset possible local subsidence. Ledgers must be level and fixed to standards with right-angle couplers. Putlogs and transoms must be firmly fixed to ledgers or standards. The flattened end of the putlog must be pushed right into the wall to provide maximum support. Putlogs and transoms should be spaced according to the expected load and the thickness of the boards to be used in the platform. In normal use, putlogs and transoms should be spaced so that the spans of scaffold boards should not be greater than :

32mm boards: 1m 38mm
boards: 1.50 m50mm
boards: 4.60 m

Ladders used in Scaffolds:

Ladders used as uprights must be:

- Strong enough to carry the load of both the work and the workers.
- Equally supported on each side.
- Secured to prevent slipping.

Ladders to be placed under an angle of 70 ° with the vertical and shall extend 1m above the railing. Ladders are only to be used to support a scaffold platform when the work is light, e.g., painting.

Stability of Scaffolds:

All scaffolds must be:

- On a solid, even base ; or suspended from a sound structure
- Braced to prevent failure, and
- Tied to the building or structure unless specially designed to be completely independent.
- Any building or structure which supports a scaffold must be strong enough to carry the scaffold and its load A scaffold only used as a working platform for workers when a scaffold also used to store material etc, a calculationis needed to check if that scaffold is safe to carry the total load. Mobile scaffolds must:
- Be stable, weighted at the base if necessary
- Be used only on a flat, level surface.
- Have the wheels locked to prevent movement whilst being used for work,
- Be pushed, or pulled only at the base when being moved. Scaffolds must not be built on loose bricks, drain pipes, chimney pots, etc. Bricks or blocks can be used to support a platform no higher than 600mm from the ground orfloor.

Slung Scaffolds

- Be strong enough
- Be properly secured to be overhead anchor-ages and to be platform frame,
- Be spaced so as to keep the platform stable,
- Be vertical, and
- Be kept straight
- No rope other than wire rope may be used for suspension
- Packing must be used to prevent damage to suspension ropes or chains at any point where sharp or rough-edgedprotrusions could cause chafing.
- The platform must be secured to prevent swaying whilst in use.

Cantilever, Jib figure and Bracket scaffolds:

Cantilever or jib scaffolds must be anchored to a structure which is strong enough to carry the total load Outriggers must be long enough and strong enough and the scaffold must be braced to ensure stability. Figure or bracket scaffolds supported by dogs or spikes must not be used if there is any danger of these pulling out of the brickwork or stone-work.

Support for Scaffolds:

No part of the building may be used to support scaffolding unless it is strong enough to do so. Unless gutters have been designed as walkways and are strong enough to bear the weight, they must not be used to support scaffolding or ladders.

Suspended Scaffolds (Not Power Operated)

The ropes, winches, block and tackle must be strong enough and correctly rigged. A safe anchorage for the suspension must be provided.

Winches or similar lifting devices must:

a. have brakes which apply when the operating lever is released, and
b. be protected from the weather, falling dirt, etc.

Outriggers must:

a. be long enough and strong enough,
b. be horizontal (light cradles are excepted)
c. have stops at their outer ends (light cradles excepted)
d. be tied down or properly counter-weighted at the tail, and
e. be close enough together to support the rails and scaffolds properly .

Counterweight Must

a. be bolted or securely attached to the outriggers, and

Runways must:

be strong enough and in good condition, have stops at each, and be bolted or tied securely to their supports

Platforms of suspended scaffolds must: be closely boarded be at least 430mm wide on light weight cradles and be atleast 600mm wide on all other types, if used only for workmen, or be at least 800mm wide, if used for workmen and materials Never be used to carry higher platform

Platforms should be as close as possible to the face of the building but where persons sit on the edge of the platform to carry out their work then the distance between platform and building can be upto 300mm

Winches must:

Have at least two full turns of rope on the drum when the platform is in its lowest position and

Be marked with the length of rope on the drum Suspended scaffolds and associated equipment must be maintained in good conditions. Platforms must be prevented from tipping or swaying whilst in use. Steel wire rope must be used for the suspension for all platforms other than light weight cradles Light cradles may be suspended by fibre ropes and pulley blocks which should not be more than 3.20m apart. (Only ropes recommended by manufacturers for this purpose should be used)

Boatswain's Chair's Cages, Skips etc. (Not Power Operated)

Hand-operated boatswain's chairs, skip etc. must:

- Be well constructed, strong enough, and properly maintained
- Have outriggers strong enough and firmly anchored,
- Have chains, ropes and lifting gear firmly secured to the outriggers above and to the chair, skip etc. Theconstruction (lifting operations) regulations apply to the lifting gear,
- Be designed so that the occupant cannot fall out
- Carry no loose materials which could interfere with the safety of occupant
- Have means of preventing spinning and tipping (a swivel connection at the suspension points is strongly advised)
- In the case of skips, be at least 910 mm deep
- Be under the supervision of a competent person during installation and use, and
- A boatswain's chair may only be used as a workplace when the work would not take long enough to make the useof a suspended (or standard) scaffold reasonably practicable.
- Persons working in these must wear fall protection harnesses connected to a rope or chain separate from the chairor skip suspension rope or chain.

SECTION 16: HOISTS, CRANES AND DERRICKS

Safety of Hoist ways, Platform and Cage:

Hoist ways must be enclosed wherever access is provided or wherever persons could be struck by the platform or other moving parts. Gates must be fitted in the enclosure at all landing places and must normally be at least 2m high, but gates 910 mm high are acceptable where persons are not at the risk of falling down the hoist ways or coming into contact with moving parts. Gates must be kept closed except for the movement of men and materials; it is the duty of all persons to ensure it is done. Hoists platforms and cages must be fitted with a device capable of supporting them, fully loaded, should hoists, ropes or driving gear fail. Hoists must be fitted with verrun stops at the top.

Operation of Hoists

a) Hoists must only be capable of being operated from one position at a time, whether by rope, lever or switch. Hoists mustnot be operated from the cage.

b) Where the hoist driver cannot see the platform or cage during it s movement, a signaling system, which covers all landingplaces, must be used.

c) All hoists, prior to their use, have to be inspected by a competent person

Safe Working Load and Marking of Hoists

a) The platform of materials or goods hoists must carry a notice stating

(i) the safe working load and

(ii) that the passenger must not ride on platform

The safe working load must not be exceeded except for test purposes.

b) Cages for passengers hoists must carry a notice stating

(i) the safe working load and

(ii) the number of passengers permitted.

No greater number of passengers may be carried and safe working load must not be exceeded except for the test purposes.

SECTION 17: MOTOR VEHICLES

A site traffic plan must be developed at the beginning of the project to control all traffic on site and movement of materials, parking etc. Motor equipment left unattended at night near areas where work is in progress must have appropriate lights, reflectors or barricades to identify the locations of the equipment. A safety tie rack, cage, or equivalent protection must be used

when a worker is inflating, mounting, tires installed on split rims or rims equipped with locking rings. Heavy machinery that is suspended or held aloft by the use of slings, hoists, or jacks must be blocked or cribbed to prevent falling or shifting before employees are permitted to work under them. Bulldozer and scraper blades and similar equipment shall be either fully lowered or blocked when being repaired or when not in use. All controls must be in the neutral position and the motor stopped and brakes set, unless work being performed requires otherwise. Parked equipment must be checked and parking brakes set. All cab glass shall be safety glass. All vehicles must have a service brake system, an emergency brake system, and a parking brake system. Vehicles that require additional light shall have at least two headlights, as well as brake lights. The vehicles must also be equipped with back horn which automatically sets off as and when the vehicle is in reverse gear. Other standard vehicles equipment such as seat belts, rear-view mirrors and safety latches on operating levers shall be in accordance with standard vehicle codes, and state-inspected where appropriate. The authorized individuals with valid driving license only shall be allowed to drive.

SECTION 18: BARRICADES

(i) Contractor shall erect and maintain barricades required in connection with its operation to guard or protect,

a) Hoisting areas.

b) Areas adjudged hazardous by contractor's safety management and/ or Project Manager's Inspectors

c) 's existing property subject to damage by the contractor's operations

(ii) Contractor's employees and those of his subcontractors shall become acquainted with Project Managers barricadingpractice and shall respect the provisions thereof.

Guarding of floor opening and floor holes:

Every temporary floor opening shall have railings, or shall be constantly attended by Supervisors appointed by Contractor's safety officer / Manager. Every floor hole into which persons can accidentally fall shall be guarded by either:

a) A railing with toe board on all exposed sides, or

b) A floor hole cover of adequate strength and it should be hinged in place. When the cover is not in place, the place the floor hole shall be constantly attended by some one or shall be protected by a removable railing. Barricades must be strong enough to carry the weight of people. Every stairway floor opening shall be guarded by a railing on all exposed sides, except at entrance to stairway. Every ladder way floor opening or platform shall be guarded by a guard railing with toe board on all exposed sides (except at entrance to opening) with the passage through the railing either provided with a swinginggate or so offset that a person can not directly into the opening.

Guarding if open-side floors and platform

Every open-sided floor or platform 120cm or more above adjacent floor or ground level shall be guarded by a railing (or the equivalent) or all open sides except where there is entrance to ramp, stairway or fixed ladder. The railing shall be provided with a toe board beneath the open sides wherever,

(a) Persons may pass,

(b) there is moving machinery and

(c) there is equipment with which failing materials could create a hazard

SECTION 19: HANDLING AND STORAGE OF MATERIALS

Cement:

Storage and stacking: Cement shall be stored at the work site in a building or a shed which is dry, leak proof and moisture proof. The building or shed for storage should have minimum number of windows and close fitting doors and these should be kept closed. Cement received in bags shall be kept in such a way that the bags are kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags shall be stacked off the floor on wooden planks in such a way as to keep

them 150 to 200mm clear from the floor and space of 450mm minimum shall be left all round between the exterior walls and in the stacks. In the stacks the cement shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on bottom layer of bags sometimes 'warehouse pack' is developed in these bags. This can be removed easily by rolling the bags when cement is taken out for use. The height of stack shall not be more than 15 bags to prevent the possibility of lumping up under pressure. The width of the stack shall be not more than four bags length or 3m. In stacks more than eight bags high, the cement bags shall be

arranged alternately lengthwise and crosswise so as to tie the stacks together and

minimize the danger of toppling over. For extra safety during monsoon or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a water proofing membrane such as polyethylene, which shall close on the top of the stack. Care shall be taken to see that the waterproofing membrane is not damaged any time during the use. Drums or other heavy containers of cement shall not be stacked more than two

layers high. The manner of storage shall facilitate the requirement that lots of cement received are removed and used more or less in the order in which they are received.

Handling – Hooks shall not be used for handling cement bags unless specifically permitted by the engineer-in-charge.

Polyethylene pipes

(a) Storage & stacking:

Black polyethylene pipes may, be stored either under cover or in the open. Natural polyethylene pipes however, should be stored under cover and protected from direct sunlight. Coils may be stored either on edge or stacked flat one on top of the other, but in either case they should not be allowed to come into contact with hot water or steam pipes and should be kept away from hot surface. Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set. Storage of pipes in heated areas exceeding 270 C should be avoided.

(b) Handling: Removal of pipe from a pile shall be accomplished by working from the ends of the pipe.

Pipes of conducting materials:

(a) Storage and stacking: Pipes shall be stacked on solid level sills and contained in a manner to prevent spreading or rolling of the pipe. Where quantity storage is necessary suitable packing shall be placed between succeeding layers to reduce the pressure and resulting spreading of the pile. In stacking and handing of pipes and other conducting materials the following minimum safety distances shall be ensured from the overhead power line:

11KV and below 40m

Above 11and below 33KV 60m Above
33 and below 132KV 70m Above 132
and below 275KV 70mAbove 275and
below 400KV 50m

(b) Handling: Removal of pipes from a pile shall be accomplished by working from the ends of the pipe. Duringtransportation, the pipes shall be so secured as to ensure against displacement.

Paints, Varnishes and Thinners:

(a) Storage and stacking: Paints, varnishes lacquers, thinners and other flammable materials shall be kept in properly sealed or closed containers. The containers shall be kept in a well ventilated location, free from excessive heat, smoke, sparks or flame. The floor of the paint stores shall be made up of 10cm thick loose sand and stored in a collection drip pan to prevent leakage's to the ground and/or the soil.

Paint materials in quantities other than required for daily use shall be kept stocked under regular storage place. Where the paint is likely to deteriorate with age the manner of storage shall facilitate removal and use if lots in the same order in which they are

received. Temporary electrical wiring / fittings shall not be installed in the paint store. When electric lights, switchesor electrical equipment are necessary, they shall be of explosion proof design.

(b) Handling: Ventilation shall be adequate to prevent the accumulation of flammable vapors to hazardous levels of concentration shall be provided in all areas where painting is done.

When painting is done in confined spaces where flammable or explosive vapors may develop any necessary heat shall be provided through duct work remote from the source of flame. Sources of ignition such as open flame and exposed heating elements shall not be permitted in area or rooms where spray painting is done nor shall smoking be allowed there. Careshould be taken not to use any naked flame inside the paint store. Buckets containing sand shall be kept ready for use incase of fire. Fire extinguisher when required shall be of foam type confirming to accepted standards.

Bitumen, Road Tar, Asphalt etc.:

(a) Storage and stacking: Drums or containers containing all types of bitumen, road tar, asphalt etc. shall be stacked vertically on their bottoms in upto 3 tiers. Leaky drums shall be segregated and either their contents shall be emptied intointact drums or contained in larger containers. All spillages or leakages onto natural soil shall be immediately cleaned up and placed in a contained area. Empty drums shall be stored in pyramidal stacks neatly in rows.

(b) Handling: Bitumen / Tar – Bitumen / tar shall not be heated beyond the temperature recommended by the manufacturer of the product. While discharging heated binder from the boiler, workers shall not stand opposite to the jet so as to avoid the possibility of hot binder falling on them. The container shall be handled only after closing the control valve. While handlinghot bitumen / tar, workers shall exercise scrupulous care to prevent accidental spillage thereof. The buckets and cans inwhich the hot material is carried from boiler shall be checked before use to ensure that they are intact and safe. Mops and other applicators contaminated with bituminous materials shall not be stored inside buildings

Bituminous roofing felts:

(a) Storage and stacking: Bituminous roofing felts shall be stored away from other combustible, flammable materials. Forlong storage it shall be kept under shade.

(b) Handling: Bituminous roofing felts should be handled in a manner to prevent cracking and other damages

Flammable materials:

(a) Storage and stacking: In addition the following provisions shall also apply: Outdoor storage of drums required some care to avoid contamination because moisture and dirt in hydraulic brake and transmission fluid, gasoline or lubricants may cause malfunction of failure or equipment with possible danger to personnel. The storage area should be free of accumulations of spilled products, debris and other hazards and Compressed gases and petroleum products shall not be stored in the same building or close to each other.

(b) Handling: Petroleum products delivered to the job site and stored there in drums shall be protected during handling to prevent loss of identification through damage to drum markings, tag, etc. Unidentifiable petroleum products may result in improper use with possible fire hazard damage to equipment or operating failure. Workmen shall be required to guard carefully against any part their clothing becoming contaminated with flammable fluids. They shall not be allowed to continue work when their clothing becomes so contaminated. All flammable and toxic liquids shall be stored in suitable collecting drip pans to avoid spill contamination into the ground/soil. All workers shall be provided training as part of the induction as to how to correctly handle and lift materials and the maximum load they can lift or handle at any point.

SECTION 20: EXCAVATION AND SHORING

Excavation and Trenching: All trenches, 1.5m or more in depth, shall at all times be supplied with at least one ladder for each 30m in length or fraction thereof. Ladder shall be extended from bottom of trench to at least 1meter above surface of the ground. Sides of a trench which is 1.5m or more in depth shall be stepped back to give suitable slope or securely held by timber bracing so as to avoid the danger of sides collapsing. Excavated material shall not be placed within 1.5m of edge of trench of half of depth of trench, whichever is more cutting undermining or undercutting be done. Safety procedures for the operation of the excavation and grading equipment (such as the safe distance from excavations) should be developed.

SECTION 21: CONCRETE CONSTRUCTION

Handling of plant

Mixers: All gears, chains and rollers of mixers shall be properly guarded. If the mixer has a charging skip the operator shall ensure that the workmen are out of danger before the skip is lowered. Railings shall be provided on the ground to prevent anyone walking under the skip while it is being lowered. All cables, clamps, hooks, wire ropes, gears and clutches etc. of the mixer, shall be checked and cleaned, oiled and greased and service once a week. A trial run of the mixer shall be made and defects shall be removed before operating a mixer. When workmen are cleaning the inside of the drums and operating power of the mixer shall be locked in the off position and all fuses shall be removed and a suitable notice hung at the place.

Trucks:

When trucks are being used on the site, traffic problems shall be taken care of. A reasonably smooth traffic surface shall be provided. If practicable, a loop road shall be provided to permit continuous operation of vehicles and to eliminate their backing. If a continuous loop is not possible a turnout shall be provided. Backing operations shall be controlled by a signalman positioned so as to have a clear view of the area behind the truck and to be clearly visible to the truck driver. Movement of workmen and plant shall be routed to avoid crossing as much as possible the truck lanes.

Formwork:

Formwork shall be designed after taking into considering spans, setting temperature of concrete, dead load and working load to be supported and safety factor for the material used for formwork. All timber formwork shall be carefully inspected before use and members having cracks and excessive knots shall be discarded The vertical supports shall be adequately braced or otherwise secured in position that these do not fall when the load gets released or the supports are accidentally hit. Tubular steel centering shall be used in accordance with the manufacturer's instructions. When tubular steel and timber centering isto be used in combination necessary precautions shall be taken to avoid any unequal settlement under load.

All centering shall be finally inspected to ensure that:

a) Footings or sills under every post of the centering are sound
b) All tower adjustment screws or wedges are snug against the legs of the panels.
c) All upper adjustment screws or heads of jacks are in full contact with the formwork.
d) Panels are plumb in both directions.
e) All cross braces are in place and locking devices are in closed and secure position.
f) In case of chajjas and balconies the props shall be adequate to transfer the load to the supporting point.

Ramps and gangways:

Ramps and gangways shall be of adequate strength and evenly supported. They shall either have a sufficiently flat slope or shall have cleats fixed to the surface to prevent slipping of workmen. Ramps and gangways shall be kept free from grease, mud, snow or other slipping hazards or other obstructions leading to tripping and accidental fall of workman. Ramps andgangways meant for transporting materials shall have even surface and be of sufficient width and provided with skirt boardson open sides.

Pre-stressed concrete:

In pre-stressing operations, operating, maintenance and replacement instructions of the supplier of the equipment shall be strictly adhered to. Necessary shields should be put up immediately behind the pre-stressing jacks during stressing operations. Wedges and other temporary anchoring devices shall be inspected before use. The pre-stressing jacks shall be periodically examined for wear and tear. A spreader beam shall be used wherever possible so that the cable can be as perpendicular to the members being lifted as practical. The angle between the cable and the members to be lifted shall not be less than 600. Methods of assembly and erection specified by the designer, shall be strictly adhered to at site. Immediately on erecting any unit in position, temporary connections or supports as specified shall be provided before releasing the lifting equipment. The permanent structural connections shall be established at the earliest opportunity.

Heated concrete:

When heaters are being used to heat aggregates and other materials and to maintain proper curing temperatures, the heaters shall be frequently checked for functioning and precautions shall be taken to avoid hazards in using coal, liquid, gasor any fuel.

SECTION 22: MASONARY WORK

Walls

General: Depending on the type of wall to be constructed the height of construction per day shall be restricted to ensure that the newly constructed wall does not come down due to lack of strength in the lower layers. Similarly, in long walls adequate expansion / crumple joints shall be provided to ensure safety.

Opening in walls: Whenever making of an opening in the existing walls is contemplated, adequate supports against the collapse or cracking of the wall portion above or roof or adjoining walls shall be provided. Guarding of wall openings and Holes: Wall opening barriers and screens shall be of such construction and mounting that they are capable of withstanding the intended loads safely. For detailed information reference may be made to good practice. Every wall opening from which there is a drop of more than 120mm shall be one of the following: Rail, roller, picket fence, half door or equivalent barrier:The guard may be removable but should be preferable be hinged or otherwise mounted so as to be conveniently replaceable. Where there is danger to persons working or passing below on account of the falling materials, a removable toe board or the equivalent shall also be provided. When the opening is not in use for handling materials the guards shall be kept in position regardless of a door in the opening. In addition a grab handle shall be provided on each side of the opening. The opening should have a sill that projects above the floor level at least 2.5cm. Extension platform into which materials may be hoisted for handling, shall be of full length of the opening shall be of full length of the opening and shall have side rails orequivalent guards. Every chute wall opening from which there is a drop of more than 120mm shall be guarded by one ormore of the barriers specified in 16.2.1 or as required by the

conditions.

SECTION 23: HEALTH & HYGIENE STANDARDS

Drinking water:

a) In every work place, there shall be provided and maintained at suitable places, easily accessible to labour, a sufficientsupply of cold water fit for drinking.

b) Where drinking water is obtained from an intermittent public water supply, each work place shall be provided with storage where such drinking water shall be stored.

c) Every water supply or storage shall be at a distance of not less than 50 feet from any latrine drain or any other source

ofpollution.

Washing facilities:

a) In every work place adequate and suitable facilities for washing shall be provided and maintained for the use of contractlabour employee therein
b) Separate and adequate cleaning facilities shall be provided for the use of male and female workers
c) Such facilities shall be conveniently accessible and shall be kept in clean and hygienic condition.

Latrines and Urinals

a. (a). Latrines shall be provided in every work place on the following scale namely:

(i) Where females are employed there shall be at least one latrine for every 25 females.

(ii) Where males are employed there shall be at least one latrine for every 25 males.

b. Provided that where the number of males or females exceeds 100, it shall be sufficient if there is one latrine for 25males orfemales as the case may be upto first 100 and one for every 50 thereafter.

c. Every latrine shall be under cover and so partitioned off as to secure privacy and shall have proper door and fastenings.

d. Construction of latrines: The inside walls shall be constructed of masonry or some suitable heat-resisting non-absorbent materials and shall be cement washed inside and outside at least once a year, latrines shall not be of standard lower than borehole system.

(i) Where workers of both sexes are employed, there shall be displayed out side each block of latrine and urinal a notice inthe language understood by the majority of the workers "for men only" or for" women only" as the case may be.
(ii) The notice shall also bear the figure of man or woman as the case may be.

e. There shall be at least one urinal for male workers upto 50 and for female workers upto 50 employed at a time, provided that where the number of male or female workers as the case may exceed 500 it shall be sufficient if there is one urinal for every 50 males or females upto the first 500 and one for every 100 or part thereafter.

(i) The latrines and urinals shall be adequately lighted and shall be maintained in a clean and sanitary condition at all times
(ii) Latrines and urinals other than those connected with flush sewage system shall comply with the requirements of Public Health Authorities.

f. Water shall be provided by means of tap or otherwise so as to conveniently accessible in or near the latrines and urinals.

g. Disposal of excreta: Unless otherwise arranged by the local sanitary authority, arrangements for proper disposal of excreta by incineration at the work place shall be made by means of a suitable incinerator. Alternately excreta may be disposed of by putting a layer of night soil at the bottom of pucca tank prepared for the purpose and covering it with 15cm layer of waste or refuse and then covering it with a layer of earth for a fortnight (then it will turn to manure)

(i) The contractor shall at his own expense, carry out all instructions issued to him by the Engineer-in-charge to effect proper disposal of night soil and other conservancy work in respect of the contractor's workmen or employees of the site. The contractor shall be responsible for payment of any charges which may be levied by the municipal or cantonment authority for execution of such on behalf.

Provision of shelter during rest:

At every place there shall be provided free of cost, for suitable sheds two for meals and other two for rest separately for the use of men and women labour. The height of each shelter shall not be less than 3m from the floor level to the lowest part of the of the shed roof. These shall be kept clean and the space provided shall be on the basis of 0.6sqm per head. Providedthat the engineer-in-charge may permit subject to its satisfaction, a portion of building under construction or other alternative accommodation to be used for the purpose.

Café/Eating place:

a. In every work place where the work regarding the employment of contract labour is likely to continue for six months and where in contract labour numbering 100 or more are ordinarily employed an adequate place shall be provided by the contractor for the use of such labour.

b. The café shall be maintained by the contractor in an efficient manner.

c. The café shall consist of at least a dining hall, cafe, storeroom, pantry and washing places separately for workers andutensils.

d. The floor shall be made of smooth and impervious materials and inside walls shall be lime washed or colour washed at least once a year. Provided that the inside walls of the cafe shall be lime washed every four months.

e. The premises of the cafe shall be maintained in a clean and sanitary condition

f. Suitable arrangements shall be made for the collection of disposal of garbage.

g. Waste water shall be carried away in suitable covered drains and shall not be allowed to accumulate so as to cause nuisance.

h. The dining hall shall accommodate at a time 30% of the contract labour working at a time.

i. The floor area of the dining hall, excluding the area occupied by the service counter and any furniture except tables andchairs shall not to be less than 1sqm per diner to be accommodated as prescribed in sub-rule (i)

j. There shall be provided and maintained sufficient utensils crockery, furniture and any other equipment necessary for efficient running of cafe

k. The furniture, utensils and other equipment shall be maintained in clean and hygienic condition.

l. Suitable clean clothes for the employees serving in the café shall be provided and maintained.

m. A service counter, if provided shall have top of smooth and impervious material.

n. Suitable facilities including an adequate supply of hot water shall be provided for the cleaning of utensils and equipment.

o. A portion of the dining hall and service counter shall be partitioned off and reserved for women workers in proportion totheir number.

p. Sufficient tables stools or benches shall be available for the number of diners to be accommodated as prescribed in subrule (i)

q. The food stuff and other items to be served in the cafe shall be in conformity with the normal habits of the contract labour.

r. The charges of food stuffs, beverages and other items served in the cafe shall be based on 'No profit no loss' and shall beconspicuously displayed in the cafe.

s. In arriving at the price of the foodstuffs and other article served in the cafe, the following items shall not be taken in toconsideration as expenditure namely:

t. The rent of land and building

u. The depreciation and maintenance charges for the building and equipment provided for the cafe.

v. The purchase, repairs and replacement of equipment including furniture, crockery, cutlery and utensils.

w. The water charges and other charges incurred for lighting and ventilation

x. The interest and amount spend on the provision and maintenance of equipment provided for the cafe.

y. The accounts pertaining to the cafe shall be audited once every 12months

z. by registered accountants and auditors.

Anti-malarial precautions:

The contractor shall at its own expense, conform to all anti-malarial instructions given to him by Engineer-in-charge including the filing up of any borrow pits which may have been dug by him.

SECTION 24: RESPONSIBILITIES

S&H –coordinators:

In connection with (Indian Regulations and standards) the tasks and responsibilities of the S&H coordinator(s) as well as the design- as the construction phase, are as follows:

Design phase:

- Co-ordination of the general aspects with respect to Safety, Health and Welfare.
- Taking care of the set-up of a S&H-plan 'in draft'.
- Putting together the S&H-file.
- Keep up and actualize the S&H-plan 'in draft' -and file.
- Hand-over the S&H-plan 'in draft' -and file to the S&H-coordinator(s) for the construction phase.

Construction phase:

- Organizing and coordinating the cooperation between employers.
- Coordinating the Safety, Health and Welfare measures by the employers.
- Coordinating supervision to meet the joint facilities.
- Give indications to the .
- Coordinating the information to the employees.
- Take measures to assure that only persons which are entitled to can come in at the works.
- Keep up and actualize the S&H-plan 'in draft' -and file.
- Handover the S&H-file to the principal.

SECTION 25: COMMUNICATION

Kick-off meeting

The kick-off meeting should be seen as a start up meeting, preliminary to the general or project oriented activities. In the kick-off meeting, besides technical relevant information, pay attention to the aspects of safety and health in general sense. The Contractor will be required to provide their job site safety program either at kickoff meeting or within a time period as determined by Project Manager after the kickoff meeting along with other pre-start documentation.

Pre-job meeting

The Pre-job meeting is meant for consultation before the activities may start. A part of this meeting is reserved to make detail appointments for specific Plant or Location directed safety- and health matters and 'actual' deviations of the normal situation. This meeting is meant as a supplement to the general information which already has been handed over during the kick-off meeting. At this meeting the **Pre-job Checklist** should be handled and worked out with all persons involved.

Progress Meeting:

The progress meeting is meant to get an update from contractors on project progress and resolve any construction/ coordination issues. It is normally held on weekly basis. This meeting will have EHS component and following items shall be discussed under this head.

Major safety issues at site Actions being taken to resolve them

Toolbox meeting:

Toolbox meetings are company (contractor) internal matters. With this kind of meeting, employees supposed to execute the job are informed about the most actual state of the activities. This information can be appointments, instructions which arethe result of above mentioned meetings. A toolbox meeting is a medium to inform 'executing employees'. Copies of these toolbox meetings (incl. registration forms) should be attached to this chapter.

Safety Meeting:

Safety meetings shall be held on weekly basis to be attended by Project Manager's Safety representative and safety officer from all contractors as well as their subcontractors. The meeting shall be chaired by Project Manager's safety representative and Project Manager may also like to attend the meetings randomly. The topics to be covered shall broadly include:

a. Safety issues at job site
b. Review pre task plans
c. Discuss safety statistics
d. Review safety committee reports/ recommendations
e. Discuss safety training initiatives
f. Review overall job site safety

SECTION 26: INFORMATION

General S&H-instructions

Everyone, who is doing activities at the Client site, should be registered at the job site. After registration, everyone get a Contractor Safety Instruction (video presentation). This presentation shows an explanation on the S&H policy, the most important emergency measures (Fire and Gas alarms) and shows general behavior rules and procedures.

Site Specific S&H-instructions

These instructions can be given when the common interest is served (equal for all facilities and departments) and the necessity exists. Examples are: LoTo, shutdown, etc. Site specific, S&H instructions, needed for this project to follow are as under;

_____.

SECTION 27: PRE TASK PLANS (PTP)/ JOB TASK HAZARD ANALYSIS (JTHA)

PTP/ JTHA is the process of systematic investigation of a task and its subtasks, ascertaining the risks associated with carrying out activities associated with those tasks, listing preventive measures to avoid potential hazards associated with executing that activity and developing contingency plan in case of emergencies. The Standard Operating Procedure of the Project Manager will serve as reference guidelines for the tasks which require development of PTP/ JTHA. However, the listis not all inclusive and if the Project Manager/ Project Manager's safety representative/ 's safety representative determine that the PTP/ JTHA is

required for some other tasks too, the contractor will be obligated to provide that as per the procedure and in the format as indicated by Project Manager (copy of format attached with these guidelines. Subsequent to the kick-off meeting, within the specified time period, the contractor will also provide the list of tasks against which PTP/ JTHA shall be submitted along with the expected time, when it would be submitted. This listing shall be done on the format shown below;

LIST OF PRE-TASK PLANS TO BE SUBMITTED ON THE *Project Name*	
Contractor:	**Trade Package:**

TASK	TIME OF EXECUTION	TARGET PTP SUBMISSION DATE

SECTION 28: ENVIRONMENT

Waste Disposal

Waste originated from activities at the project site should be dumped at the designated location in the designated manner as indicated by / PM. Chemical waste (air-sprays, oil, paint etc.) should be collected separately and, if property of client, shall be offered to the facility / department. This in conjunction with the waste-coordinator of the department concerned, or the In &out Clean department. In case the waste coordinator does not require the chemical waste for re-usage, the contractor will

dispose it off at its own expense at the designated location in the designated manner as directed by Project Manager and in accordance with all Indian Environmental Laws. Chemical waste which originates from Contractor's works should be collected and carried away by Contractor according to the legal regulations. The In & Out Clean department should be informed before carrying away the waste.

Material Safety Data Sheets (MSDS)

The Contractor is obligated to inform about the risks and dangers associated with handling of chemical and hazardous substances at site. Therefore, the information transfer in the form of Material Safety Data Sheets is necessary. The contractor shall list all materials to be used at project site that require submission of MSDS and submit those. The material shall be brought to the site only after obtaining prior approval from 's representatives on the MSDS.

Contractor is required to provide Material Safety Data sheets (MSDSs) for any chemical brought on site. An index of MSDSs for all products proposed to be used on site must be provided. In so far as possible, "environmentally friendly" products should be used (e.g. detergent or citrus based cleaners rather than solvent based cleaners). Low-Volatile Organic Compound (VOC) products should be used at all times. Chlorinated solvents should not be brought on site except on a pre-approved case-by-case basis. The Client/ reserves the right to reject any chemical proposed to be brought on site. Any regulated wastes generated on site (e.g. hazardous, residual or special waste, including regulated wastewaters, waste oil, waste paint), in must be disposed of by Contractor in strict accordance with federal, provincial and municipal or and local standards. No wastes may be disposed of down the drain or in the Client installed dumpster without prior written consent. Contractor must have appropriate training for the work to be done. Training records must be produced upon demand. Contractors must bring appropriate tools, equipment, safety devices and clothing to the job site. No tools or equipment maybe borrowed from the Client without prior written consent.

Material	MSDS sheet to be submitted by

SECTION 29: REPORTING

The contractor will submit the Monthly man-hour & safety report on the format enclosed in EHS guidelines. The report will be submitted by_ hrs. on_day of every month. In addition, should the Project Manager require any interim man-hourreports on weekly basis or any other frequency determined by Project Manager, those will also be submitted by the contractor. Safety reports submitted are in no way linked with the requirement for submission of Daily report on the part of contractor.

CONTRACTOR HEALTH AND SAFETY Sl. No…… Date……
General information (To be Completed by Safety officer)
Contractor Name : Project Name : On site contractor Representative / Supervisor / Safety
Location of Infraction : Description of Infraction: Observed By : Date : Time :
Status of Project : Project Stopped until correctionProject Continuing W/infraction Corrective Actions Required by (Date/time)
CORRECTIVE ACTION (To be Completed by the Contractor)
Corrective Action : Corrective Action Performed by :Date / time : Name : Signature :
Return to GU
CORRECTIVE ACTION FOLLOW UP (To be completed by Project Manager)
Received / Certified By : GU Date : Remarks :

GALGOTIAS UNIVERSITY

EHS DECLARATION

From:

Name of the Contractor
Name of the organizationTo:

Project Manager

Location – Pin code

Subject: EHS Declaration

I/ we hereby declare to accept the responsibility to carry out the work safely. I/ we have understood the hazards associated with site activity and developed the relevant safety procedures, trained the man power and provided required PPE and equipment. I/ we or the workers working under my/our control will adhere to the site safety rules and EHS

guidelines as stated in this document. The following are the safety practices that will be followed in addition to any other requirements as recommended by Project Manager's EHS Manager/ Site safety officer to work safely at site.

1. Wear safety helmet, safety shoes, eye protection with side shields.
2. Wear safety harness and hooking to the life line rope.
3. Wear appropriate hand gloves like cotton, leather, PVC, rubber or surgical hand gloves.
4. Proper tools will be used and checked for defects and replaced whenever required.
5. Welding torch with ring guard, welding shield, leather hand gloves required.
6. No steel rod will be used as earthing on to the welding machine.
7. Proper working platform with hand rail will be used while working at heights.
8. a) Housekeeping will be done on daily basis and the debris, sand, concrete materials and mortar will be removed andstored at identified place.
9. b) Papers, plastic sheets, rubber materials and wooden pieces have to be put in recycle bin from the work place and thiswill be sent outside the site.
10. I/ we will be appointing one safety officer, safety stewards and group leader of safety.
11. My/ our workmen and I/ we will not create any problem, quarreling with other agents.
12. I/ we will be providing fire extinguishers, fire buckets with water and sand in work place.
13. First aid facility and hospital facility will be provided to my/ our workman.
14. I/ we will be conducting the safety training programs for my/ our workmen, like first aid, fire fighting and safety.
15. I/ we will obtain work permits to work for hazardous area.
16. As per the contract document, we agree with imposition of penalty on us should we violate
17. any safety norms/ practices at the project site, which can be deducted from our invoices.
18. I/ we will submit all the required insurance policies as per the contract documents.

Signature of the contractor

GALGOTIAS UNIVERSITY

PERSONAL PROTECTIVE EQUIPMENTS CHECKLIST

SL.NO PARTICULARS YES / NO

1 Do the Workers Wear Helmet in such a way to protect their head?

2 Are they wearing hand gloves, Rubber gloves (IS 4770 for electrical purpose), Leather hand gloves of required quality forthe job

3 Do the workers using appropriate Footwear?

4 Is there any need for Safety harness (IS 3521-1965) use? If so, are they hooked property?

5 Is there any need for Ear protection? If so, are they using the device external or internal type?

6 Are the workers wearing Safety glasses / Safety screens /Safety goggles for the work being done? If so, are they usingappropriate equipment?

7 Do the Workers have respirator/ protection from inhalation

hazards?8 Are the helpers also using proper PPE or not?

9 Have the Workers been briefed about the Hazards associated with the job and the emergency action to be followed whenever there is requirement?

EHS Manager/ Site Safety Officer Contractor's Site In-charge/ Safety In-charge

GALGOTIAS UNIVERSITY

PERMIT FOR WORKING AT HEIGHTS

Permit No.: Date:

Project Name: Location:

Contractor: Sub-contractor:

Job description: Area/ location:

A	**SCAFFOLDING & RELATED PROTECTION**	Y	N	N/A
A.1	Scaffolding good construction, adequate strength with 50 cm clear walk ways toeboards with wide screens,			
A.2	Scaffold well secured with stair ways, hand rails. Should be wide enough to pass two persons at a time			
A.3	Maintained good Housekeeping at work location / site			
B	**OVERHEAD CLEARANCE**			
B.1	Required clearance available from all overhead electrical cables			
B.2	**LADDERS**			
B.3	Strong material, well maintained ladders			
B.4	Ladder not placed against loose boxes materials, sound objects, near electricalinstallation.			
B.5	Ladder of sufficient height used, on top tied down and man positioned at the foot at ladder.			
B.6	Safety Footwear provided			
B.7	Ladder placed at an angle of 70 to 75 degrees			
B.8	Area of work barricaded so no person can walk under the ladder.			
C	**PERSONAL PROTECTION EQUIPMENT**			
C.1	Safety harness provided and worn			
C,2	Safety helmet, safety shoes and any other PPE required to perform the job at hand is provided and worn properly			

A. Permission:

Permission granted from _____to_____hrs.on_____

Time_____Date_____Signature of permit issuing authority

B. Receipt:

I hereby declare that I accept the responsibility for carrying out the work as detailed on this permit and no attempt will bemade by me or men under my control to carryout any other work.

Time_____Date _____Signature of Person Receiving Permit

C. Clearance certificate:

Work completed by taking all precautionary steps as approved by permit issuing authority.

Time_____Date _____Signature of Person completing jobs

D. Cancellation:

This permit to work is hereby cancelled.

Time_____Date _____Signature of permit issuing authority/Shift in-charge

GALGOTIAS UNIVERSITY

HOT WORK PERMIT

Permit No.: Date:

Name of the Project: Location:

Name of the Contractor: Sub-Contractor:

A) Person taking permit /permittee to fill up:

1) Exact location where hot work is being planned_____

2) Approximate duration of work From: Date:_____Start Time_____ Finish Time_

Revalidated To: Date:_____ Start Time_____Finish Time_

3) Description of work:

4) Tools & Tackles used:

Points to be checked

SL No	Details	Y	N	N/A
1	Has the area immediately below and adjacent to the work spot been cleared/removed of oil, grease and waste cotton etc?			
2	In case of Gas welding, proper hose pipes and pressure gauges are used?			
3	Have fire extinguishers been kept handy at site?			
4	Has tin sheet / wet gunny bag / fire retardant cloth/ sheet been placed to prevent sparks from causing fire?			
5	Have fire sand buckets been kept handy at site?			
6	Whether cylinders are kept in upright positions?			
7	Whether Proper PPE's are available?			
8	In Electrical Welding whether proper Earthing is provided.			

The above points have been complied with and conditions rendered safe / hazards innocuous to undertake the hot work.

Name of_____Signature _____

Designation_____

Permitee (Site engineer)

Name & Signature of Safety Officer _____

B) The person giving permit (Issuing Authority) to fill up:

After checking all the above precautions the hot work can be carried out in the above area.

1. Date:_____Time:_____Signature of safety Officer_____Permit is revalidated for the Period
2. Date:_____Time:_____Signature of Safety Officer _____

C) Time _____ Date: _ at which the permit closed & filed

GALGOTIAS UNIVERSITY

DISPOSAL PERMIT FORM

PERMIT NO.: **DATE:**

Mr._____ Foreman, is authorized to dispose of the followingmaterials in the manner indicated:

MATERIAL METHOD LOCATION

The procedures posted at the burning ground and disposal area must be followed in detail during these operations.

Personnel Authorized _____

Time: _____ Date: _____

_____

(Supervisor)

GALGOTIAS UNIVERSITY

EXCAVATION PERMIT

Permit No:_____Date: _____
Project Name:_____Location: _____

Contractor:_____Sub-contractor:_____

Excavation details:

Purpose:

_____

Area/ Location:_____
Proposed date and time for start of work: _____
Proposed date and time for completion of work:_____
Tools and equipment involved: _____

_____
_____

Length_____m Width _____m Depth_____m

Preparation

1. Underground cables, pipelines, electrical lines etc checked Yes/No
2. Personnel protective equipments to be used to include;

A. Safety Shoe Yes/No
B. Safety Helmet Yes/No
C. Gloves Yes/No
D. Eye Protection Yes/No
E. Ear Protection Yes/No
F. Nose Mask Yes/No

Safety Precautions

1. The proper approach arrangement to be made with required no. of exit points
2. Wear proper PPEs
3. Barricade area and Display Warning boards
4. Ensure good housekeeping before and after the work
5. Ensure the presence of supervisor during the execution of work
6. Use certified machinery
7. Check for possible interference with any underground utilities
8. Check reverse horn for vehicles and driver license
9. Any special safety precautions (specify)_____

Checked By:
Contractor's Safety Officer Signature Date

PERMIT ISSUING AUTHORITY (Permit is granted & valid up to)

1. Date:_____Time:_____Signature of Safety Officer _____ Permit is revalidated for the Period
2. Date:_____Time:_____Signature of Safety Officer _____

GALGOTIAS UNIVERSITY

NIGHT WORK PERMIT FORM

PERMIT NO.: _____DATE: _____

Project name:_____ Location: _____
Contractor name:_____Trade Package:_____
Activities scheduled for night work with location:

_____

Reason for conducting these activities at night:

_____

Name of the Supervisor:

Name of workers and designation:

S.No NAME DESIGNATION

Sufficient lighting provided: YES/NO Area
to be cleaned after work: YES/NO

Emergency vehicle available: YES/NO Vehicle No.:

Any other special precautions:

Signature:_____Signature:_____Signature: _____

Supervisor (Contractor) Site In charge (Main Contractor) EHS Manager

Note: CONCERNED AGENCIES ARE RESPONSIBLE FOR ANY UNSAFE ACT/
CONDITIONS

GALGOTIAS UNIVERSITY

PERMIT FOR WORKING IN AHU/ ELECT/ UPS/ SERVER/ BATTERY ROOMS

A.

Date:_____ Permit number:_____

Project:_____Location:_____
Agency requesting permit: _____
Location of work: _____
Permit to work on (date):_____From: _____To:_____
Description of work:_____

_____

Names of Individuals who will work in the area along with the name of supervisor:

_____
_____

LOTO required or not? _____
Hot work/ Height work permit taken, if required. _____
Any other precautions, if required: _____

_____

Signatures of requestor

B.

Permit granted to work on_____from_____to_____.
Signatures of authorized representative

C.

Area cleared after work: _____
Signature of rep of agency which Signatures of representative

Performed work

Copy to: 1. Workers working at site

2. representative
3. Contractor records

GALGOTIAS UNIVERSITY

CONFINED SPACE ENTRY PERMIT

A.

Date:_____Permit no.: _____

Project Name and Location: _____

Permit Requested by:_____

Confined space location:_____Confined space description: _____

Purpose of entry and description of work:_____

_____

_____

Duration of permit: From: _____To: _____

Potential hazards (Mark all that apply):

Oxygen deficiency/ Toxic gases Fire/ explosion /Mechanical hazards

B.

No. Item Yes Not Required1
Proper lighting provided

2 Proper ventilation provided (natural/ artificial)3
Full body harness with lifeline provided

4 Proper access for exit provided5
Entrance barrier provided

6 Method of isolation/ control, purge, flush, etc.7
Lockout provided

8 Respiratory protection provided
9 Rescue team with devices put on stand
by10 Proper PPE provided

11 Tests required (Attach reports):

Oxygen level (19.5% - 23%) Carbon
Monoxide level (<25 ppm)

Name of Entrants Name of Attendants (stand by team)

I have checked the above points and found the conditions compliant to undertake the abovementioned work.

_____ _____ _____

Name of permitee Signature of permitee Designation

C.

The precautions and safe conditions mentioned above have been verified and the work can be started.

_____ _____ _____

Name of Issuing authority Signatures of Issuing authority Designation

D.

Time_____ Date_____Permit closed and filed.

Signature of safety supervisor: _____

GALGOTIAS UNIVERSITY

SHAFT WORK PERMIT

Date:_____ Permit no.: _____

Project name and Location: _____

Name of the agency requesting permit: _____

Location of work: Shaft number:_____Floor:_____

Task to be performed: _____

Start date and time:_____Finish date and time: _____

Safety Precautions required:

No. Item Yes Not required

1 All personnel are wearing proper PPE
2 Workers have been briefed about hazards3 Safe access to shaft available
4 Safe working platform erected
5 Safety harness with lifeline provided
6 Fire extinguisher provided for hot work7 Shaft appropriately barricaded

Names of workmen entering shaft: _____

_____
_____

I have ensured that the safety precautions as listed above for the task to be performed have been taken for this shaft work.

_____ _____

Name of permitee Signature of permitee Designation

_____

Name of Issuing authority Signature of Issuing authority Designation Notes:

1. Separate permit required for work in each shaft.
2. Work permit is valid for the prescribed date, time and in prescribed location only.Time____Date _____Permit is closed.

Name and Signature of the Issuing authority: _____

GALGOTIAS UNIVERSITY

CONTRACTOR INCIDENT/ NEAR MISS REPORTING FORMAT

Project:_____Location: _____
Name of Contractor: _____
Name of Contractor Employee: _____Age:_____Sex:_____
Incident Date:_____ Incident Time:_____Incident Location: _____
Injuries:_____
Treated by:_____Treated at: _____
Type of Incident (First aid/ Recordable/ Lost Work day/ Fatal/ Near Miss): _____
Task assigned to person at the time of incident:_____

_____

Description of the Incident: _____

_____
_____
_____

Primary Root cause for the Incident:_____

_____
_____

Contributory factors: _____

_____
_____

Date when latest safety training was given to employee: _____
Subject of training:_____Given by: _____
Was a Pre task plan required/ submitted for this task:_____
Is there a standard procedure developed to perform this task?_____
If yes, was it reviewed with the worker and when? _____
Preventive measures proposed to avoid recurrence in future:_____

_____
_____
_____
_____

Contractor Site In-Charge Contractor Safety In-Charge

GALGOTIAS UNIVERSITY

PEP TALK REPORT FORM

(To be filled by the person conducting pep talk)

Project:_____ Location: _____
Name of Contractor:_____ Trade: _____
Name of Site In-Charge: _____
Name of Contractor Safety coordinator:_____
Number of Workmen present in Pep talk:_____
Date and Time of Pep talk: _____
Topics discussed: _____

_____
_____

Any significant problems/ issues identified:_____

_____
_____

Remarks (if any):_____

_____

Contractor Safety Representative Safety Representative

MONTHLY EHS STATISTICS REPORT – *Month, Year*

(To be filled and submitted by contractor)

Project:_____Report No:_____Date: _____
Name of Contractor:_____Trade:_____

S.No Description Status

1 No. of Man-hours worked over last month2
Cumulative Man-hours worked till date

3 No. of Reportable Accidents on project4
No. of Near Misses

5 No. of Lost Work Day (LWD) cases6
No. of Safety Pep talks conducted

7 Infraction Notices/ Safety Inspection Reports received8
Infraction Notices/ Safety Inspection Reports closed

9 No. of Fire extinguishers available at site (all types)a Foam Type (Last serviced on____)
b CO2 Type (Last refilled on_____)
c Others

10 No. of Training sessions conducted
a Fire fighting training
b First Aid training

c PPE Usage trainingd
Others

11 Safety Permits Issued
12 No. of Safety sign boards displayed at site
13 Housekeeping practices (Excellent/ V Good/ Good/ Average/ Poor)14 No. of times Equipment, Machinery and Tools inspected
15 Physical condition of the PPE in usage (Good/ Average/ Poor)16
License and vehicle documents available (if applicable)

17 Percentage compliance on the usage of PPE by workers
Submitted by:

Contractor Safety Representative/ Site In-Charge
Safety Representative Comments (if any):

_____

_____

Reviewed by:

Safety Representative Copy
to: Project Manager

GALGOTIAS UNIVERSITY

MONTHLY EHS STATISTICS REPORT – *Month, Year*

(To be prepared by contractor for submission to Client)

Project:_____Report No:_____Date: _____

Sl# Description Status

1 No. of Man-hours worked over last month2
Cumulative Man-hours worked till date

3 No. of Reportable Accidents on project4
No. of Near Misses

5 No. of Lost Work Day (LWD) cases 6 No.
of Safety Inspections conducted7 No. of
Safety Audits conducted

8 No. of Safety Infraction Notices/ Inspection Reports issued9
No. of Fire extinguishers available at site (all types)

a Foam Type (Last serviced on_____)
b CO2 Type (Last refilled on_____)
c Others

10 No. of Training sessions conducted
a Fire fighting training
b First Aid training

c PPE Usage trainingd
Others

11 No. of Safety pep talks conducted
12 Total number of Safety Permits Issued
13 No. of Safety sign boards displayed at site
14 Housekeeping practices (Excellent/ V Good/ Good/ Average/
Poor)15 Equipment, Machinery & Tools inspection (Satisfactory/
Not)
16 Physical condition of the PPE in usage (Good/ Average/ Poor)17
License and vehicle documents available (if applicable)

18 Percentage compliance on the usage of PPE by workers
19 Overall EHS implementation ((Excellent/ V Good/ Good/ Average/
Poor)Additional Comments (if any):

_____

_____

_____

Safety Representative

GALGOTIAS UNIVERSITY

MONTHLY EHS REPORT – *Month, Year*

A. MAN-HOUR LOG

Sl#	Contractor	Up to Last report	Man-hoursthis report	CumulativeManhours
1				
2				
3				
4				
5				
Grand Total:				

B. INCIDENT REPORT

Sl#	Description	Up to Last report	This report	Cumulative	Remarks
1	Near Misses				
2	Recordable Incidents				
3	Lost Work Day cases				

Sl#	Safety inspection conducted on	No. of Non conformances	No. of Open Non conformances	Remarks

Sl#	Safety Audit Conducted on	Safety Rating/ Score

Average Safety Score:

E. OVERALL JOB SITE SAFETY AND COMPLIANCE WITH EHS STANDARDS

EHS representative to indicate whether Excellent/ V Good/ Good/ Average/ Poor, as the over job site safety and compliancewith EHS Standards and also provide comments (if any).

Attachments: Monthly EHS statistics report

GALGOTIAS UNIVERSITY

PENALTY FOR NON COMPLIANCE WITH EHS GUIDELINES

A.

Project:_____Location:_____Date: _____

Penalty notice issued to: _____

Contractor Site In-charge:_____

Contractor Safety representative: _____

Description of Non-compliance: _____

_____

_____

_____

Location of non-compliance:_____

Have there been similar non-compliances in the past? _____

Have any Safety Infraction Notices been issued in the past? If yes, provide details

_____

S. No.	Degree of violation	Type of violation	Penalty for violation	No. of violations	Penalty Amount
				Total Penalty Amount	

Signature of the Safety Officer/ representative generating this notice

B.

Billing department to proceed with deduction of INR_____ as penalty amount from contractor's next running bill, fornon-compliance with EHS guidelines, duly accepted by contractor as part of tender document as well as through acceptance on EHS Declaration

form.

Signatures of Project ManagerCC
to: Client Project Manager

GALGOTIAS UNIVERSITY

CHECKLIST FOR BUILDING HOIST/ WINCH

Project:_____Location: _____

Name of Contracting agency:_____

S. No Description OK/ Not OK Remarks

A. SUPPORTING STRUCTURE:

1 Condition of steel tubes2
Condition of the Base

3 Bracing (diagonal/horizontal)4
Anchorage with structure

5 Any obstructions to the movement of rope?

B. WINCH MACHINE:

1 Condition of brakes and accessories2
Functioning of brake with load

3 Oil level and condition4
Gear box and motor

5 Coupling bolts and nuts6
Condition of wire rope

7 Anchorage of drum and wire rope8
Pawl arrangement for locking

9 Condition of diversion pulleys, idlers pulleys and fleet angle10
Limit Switches

11 Electrical connection, earthing and insulation

C. UNLOADING PLATFORM:

1 Area Barricaded
2 Stability
3 Sagging
4 Any Over
loading5 Hand
railing
6 Staging

D. OTHERS

1 Is the person authorized/experienced to Operate?
2 Does the person at unloading point use Safety
belt?3 Is the bucket overloaded?
4 Is the Signaling Man present?5 Is
the work permit Obtained?

Signature of Contractor Site In-charge Signatures of Safety Officer/ Rep.
Print Name:_____Print Name: _____

GALGOTIAS UNIVERSITY

CHECKLIST FOR SCAFFOLDING

Project:_____ Project number:_____

Name of Contractor:_____Trade: _____

S. N.	Description	Observation	Yes/ NO/ NA	Remarks / Recommend ation
1	Does the site has a practice of providing suitable and sufficient scaffolds so that the work could be safely done at a height?			
2	Is site engaging suitable/ properly trained/ experienced workmen for constructing / dismantling / shifting scaffolding works?			
3	Are scaffold platforms designed / constructed with aminimum safety factor of four?			
4	Is there a safe means of access to the workingplatform?			
5	Are scaffold structures on a solid base avoiding pavements& manhole covers?			
6	Is the scaffolding structure free from excavation pit / proper distance is maintained?			
7	Is verticality of the structure being properly maintained?			
8	Are ties for scaffold structure properly maintained (vertical as well as horizontal position)?			
9	Is there a provision of toe boards/guard rails and arethey secured?			
10	Whether planks used for working platforms are wooden /metallic?			
11	If wooden plank, whether thickness is maintained asper standard or not, viz.			
12	a. For 1.5 M span -1.5" thick			
13	b. For 2.6 M span -2.0" thick			
14	Is there a system of inspecting scaffolds by a competent person at least once a week and also afterevery prolonged interruption in the work?			
15	Is there a system of inspecting materials of scaffolds oneach occasion before erection?			
16	Is there a system of inspecting scaffolds at every spellof bad weather/ heavy wind condition?			
17	Is over hang of the working platform restricted to lessthan 50 mm/ four times the thickness of the board?			
18	Is their awareness among workmen on the importanceof load distribution on a given working platform?			
19	Is there a check for the condition and correct usage of fittings for scaffolds?			

20	Is the width of a working platform properly maintainedaccording to usage, viz.			
21	a) Minimum 600 mm for footing and not for deposit ofmaterials.			
22	b) Minimum 800 mm for footing and deposit ofmaterials.			
23	c) Minimum 1050 mm when used for heavier loads orto support higher platforms.			
24	Are all the materials stored on the platforms properlysecured or not?			

S. N.	Description	Observation	Yes/ NO/ NA	Remarks / Recommendation
25	Whether planks are tied using proper binding wires?			
26	Are openings in working platform kept safely covered / fenced?			
27	Are the scaffolds being erected on firm and levelsurface?			
28	Does the height of mobile scaffolds exceed four timesthe smaller base dimension?			
29	Are all materials stacked on platform properly securedwhile in motion?			
30	Is the safety rule: Not to ride on a scaffold while inmotion, violated.			
31	Is there a system of checking for obstructions beforethe tower is moved?			
32	Are suitable / correct lifting tackles (wire rope/ chains/ shackles) selected for suspension & used?			
33	Are all the suspension gears correctly spaced andconnected?			
34	Is there a system of using manila rope/coir rope for suspension at any place where such rope would beliable to damage by heat/flames/sharp edges etc.			
35	Are all precautionary measures taken to prevent contact between arc welding apparatus and suspension ropes?			
36	Is there a provision of guardrails and toe boards?			
37	Is hanging platform secured?			
38	Is there a provision of anchoring safety belt. Lanyardsto be tied to guy ropes?			

EHS Manager/ Site Safety Officer

Contractor Site Safety In-charge

GALGOTIAS UNIVERSITY

SAFETY INSPECTION REPORT

Project:_____Report No.:_____ Date: _____

Name of Contractor: _____

Number of non-conformities observed (as per details below): _____

Details of Non-Conformities observed:

The following non-conformances with reference to project EHS guidelines were observed during routine EHS round of the project site;

Sl. #	Description of non-conformity	Target date
1		
2		
3		
4		

Note:

Please take serious note of the above listed non-conformities and initiate corrective action immediately, so as to remove the non-conformity by the Target dates indicated above, failing which shall proceed with imposition of penalty for the observed non-conformities.

Safety Representative

Contractor's Corrective Action Response (*To be filled by contractor*):

All the above listed non-conformities have been rectified. The work is now being executed in compliance with EHS guidelines and applicable Safety Standards. The disposition of the non conformances is listed as under;

S.No	Disposition Description	Status
1		
2		
3		
4		

Contractor's Site In-Charge Contractor's Safety Representative

Dated: _____

Copy to: Project Manager

GALGOTIAS UNIVERSITY

PRE TASK PLAN FORMAT

PROJECT NAME AND LOCATION: **SCHEDULED ON:** **PTP No.:**
CONTRACTOR: **TASK:** **SUBMITTED ON:**

S.N o	Activity Description	Potential Hazard	Preventive Action	Contingency Plan
				Briefly describe the contingency plan in case the preventive actions associated with potential hazards fail to yield results and Accident/ Incident still happens. Contingency plan must list the immediate contact number of Security, Emergency, and Safety representative.

☐ To be

☐ resubmitted

Reviewed

Prepared By:

Safety officer (Contractor)

Approved By: Signature: Safety Officer

Schedule I

Performance Bank Guarantee

(On non-judicial paper of appropriate value)

(By any Nationalized Indian Bank or else obtain confirmation from ARG Outlier Media Pvt. Ltd.)

THIS GUARANTEE made on this [__] day [__] of [__] between [__] ("**Bank**") which expression shall, unless repugnant to the context or contrary to the meaning thereof, include its successors and assigns on the one part and [__], a Company incorporated in India and having its registered office at [__] ("**Client**") which expression shall, unless repugnant to the context or contrary to the meaning thereof, include its successors and assigns, of the other part.

WHEREAS Client has entered into a contract agreement ("**Contract**") at a total value of Rs. [__] with M/s. [__] (hereinafter called Contractor) which expression shall, unless repugnant to the context or contrary to the meaning thereof, includes its successors and assigns.

AND WHEREAS one of the conditions of Contract entered into, is that the Contractor make a payment of Rs. [__] being [5% (five percent)] of Contract Price in the form of a bank guarantee from a bank and in a form acceptable to the Client.

AND WHEREAS THE Contractor has requested the Bank to issue a guarantee of Rs. [__] and the Bank, through its branch at [__], has agreed to furnish this Guarantee in the manner hereunder.

NOW THIS GUARANTEE WITNESSETH that,

1. In consideration of Client, at the request of the Contractor, advancing a sum of Rs. [__], to the Contractor as and by way of Performance Guarantee, the Bank hereby unconditionally and irrevocably guarantees to the Client for due performance of the Contractor's obligations under the Contract and indemnifies the Client in respect of the amount of the Rs. [__] ("**Guarantee Amount**"). The Bank hereby undertakes, without recourse to Contractor and notwithstanding any dispute between the Client and the Contractor under the Contract or any objection by the Contractor, to pay the Client, on its mere demand in the enclosed format a sum upto and not exceeding the Guarantee Amount, being the amount of the 100% (hundred percent) of the payment or such other unadjusted amount of the said Performance Guarantee. If the Client notifies to the Bank that the Contractor has failed to observe, perform and fulfill the terms of the said Contract then the Bank shall immediately pay to the Client, on Client's mere demand in the enclosed format, such sum or sums of money to the extent of Rs. [__] being 5% (five percent) of the value of the Contract Price (as defined in the Contract) as may be claimed by the Client by reason of non-fulfillment by the Contractor of his obligations under the Contract as aforesaid / and shall also indemnify the Client against all losses and damages which may be suffered by the Client as aforesaid and against all costs, charges, expenses which may be incurred by the Client in connection herewith. The Bank shall pay the said amount without demur or protest or without recourse to the Contractor. Any such demand placed in the enclosed format on the Bank shall be conclusive proof with respect to the amount due and payable by the Bank under this Guarantee. The decision of Client as to whether the terms and conditions of this Guarantee or Contract have been observed or not shall be final and binding on Bank and the Bank will not have the discretion to withhold payment to the Client if letter in enclosed format is delivered by the Client to the Bank on or before [__] ("**Claim Period**").

2. This Guarantee is a continuing Guarantee and not revocable except with the previous written consent of the Client and as aforesaid, it will continue in force until the Contractor has maintained the schedule of delivery of the said work under the Contract and observed and fulfilled the terms and conditions of the Contract. The Client has an irrevocable and unconditional right to claim under the Guarantee in case the Guarantee required to be extended in its opinion is not extended by the Contractor or the Bank within the time frames and for the time frames stipulated by the Client.

3. The Client may, without affecting Bank's liabilities and obligations hereunder and without reference to the Bank grant time or other indulgence to or compound with the Contractor or enter into any agreement or agree to forbear to enforce any of the terms and conditions of the Contract.

4. This Guarantee shall not be affected by any change in the Constitution of the Bank, Contractor or the Client or by absorption / merger of the Client, Contractor or the Bank with any other body or corporation or otherwise and this Guarantee will be available to or enforceable by such body or corporation.

5. All composition and payments received by the Client from or on behalf of the Contractor shall be regarded as payments in gross and in the event of the Contractor being wound-up, the Client will be entitled to prove against the properties of the Contractor in respect of the whole of the contractor's indebtedness to the Client without any right on the part of the Bank to stand in the Client's place in respect of or to claim the benefits of such composition and payment or any security held by the Client until the Client shall have received the full amount of the claims against the Contractor.

6. In order to give effect to this Guarantee, the Client will be entitled to act as if the Bank were the principal debtor and the Bank hereby waives all and any of its rights of surety ship.

7. It shall not be necessary, and the Bank hereby waives any necessity, for the Client to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

8. The Guarantee herein contained is unconditional and irrevocable during its currency and will remain in full force for a period of [__] years from the date hereof ("**Expiry Date**"), or if full payment has been made to the Client by BANK, which is earlier. The Bank's liability under this Guarantee is restricted to the Guarantee Amount, i.e. Rs. [__] (Rupees [__]). The Client may claim the full or part of the amount under the Guarantee entirely at its sole discretion and make this claim at one or more times before the expiry of the Claim Period under this Guarantee. The total amount of claims is restricted to the Bank's liability under the Guarantee. The Bank is required to make a payment immediately on receipt of the claim in the enclosed format.

9. This Guarantee shall continue to be in force notwithstanding the discharge of Contractor by operation of law and shall cease only on payment of the full amount by Bank to Client of the amount hereby secured and on the claim of Client against Contractor in respect of Contract being satisfied.

10. This Guarantee shall be in addition to and not in substitution for any other guarantee or security for the Contractor given or to be given to the Client in respect of the Contract by the Bank whether alone or jointly with others.

11. In the event of force majeure, according to the Contract, the validity of the present guarantee shall be extended for a period to be mutually agreed upon by the Client and the Contractor.

12. Unless demand or claim under this Guarantee is made within the Claim Period of this Guarantee, or unless the Guarantee is renewed, or extended in writing by the Bank, all the rights of the Client hereunder shall be forfeited and the Bank shall be relieved and discharged of all liabilities.

13. Any notice by way of request, demand or otherwise hereunder may be sent by post to the Bank, addressed as aforesaid, and if sent by post, it shall be deemed to have been given at the time when it would be delivered in due course of post, and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate of posting from postal Authorities / Agencies, to the effect that the envelope was so posted shall be conclusive.

14. These presents shall be governed by and construed in accordance with Indian Law as applicable.

15. The Bank hereby declares that it has the power to issue this Guarantee and the undersigned has full power to do so.

Notwithstanding anything contained hereinabove our liability under this guarantee is restricted to the Guarantee Amount i.e. Rs. [__] (Rupees [__]). This guarantee is valid upto the Expiry Date i.e. [__]. Any claim arising out of the guarantee must be lodged with the bank at its office at [__] on or before the Claim Period i.e. [__], after which the liability of the bank would be extinguished.

In witness thereof the Bank has executed these present the day and year first above written.

Signed and delivered for and on behalf of the above named.

IMPORTANT NOTE

Following points shall be taken care of while submitting the Bank Guarantee: -

2. The Bank Guarantee shall be on non-judicial stamp paper having a value of Rs. 200/- or as per requirement stamp paper should be purchased in the name of the Bank, who gives the guarantee and not in the name of the supplier/ sub-contractor.

3. The Bank Guarantee shall be strictly as per the pro-forma.
4. Bank Guarantee should be from any of the Nationalized Banks or its subsidiaries only.
5. Correction made on the Guarantee should be endorsed by the Bank with it official seal.

NOTE: The BG format shall not be modified or changed

Schedule II

Contract Agreement

[*To be executed on a stamp paper of appropriate value*]

This Contract agreement ("**Agreement**") is entered into on this [__] day of [__] month, 2023 ("**Execution Date**") at Noida, by and among:

A. **Galgotias University, located at Plot No. 2, Sector 17A, Yamuna Expressway, Gr. Noida, Gautam Buddh Nagar, UP, India running under Smt. Shakuntla Educational & Welfare Society**, a society incorporated under the societies Act, 1860 and having its registered office at 4405/6, Prakash Appt. – 2, 5, Ansari Road, Daryaganj, New Delhi - 110002 (hereinafter referred to as the "**Client**" which expression shall unless repugnant to the meaning or context, be deemed to mean and include, its successors and permitted assignees);

B. **[__]**, a company incorporated under the Companies Act, [1956/2013] and having its registered office at [__] (hereinafter referred to as the "**Contractor**" which expression shall, where the context so admits, include its successors in office and assignees.

The Client and the Contractor are collectively referred to as the "**Parties**" and individually as "**Party**".

WHEREAS:

A. The Client had invited Bidders (as defined in the Instruction to Bidders ("**ITB**")) with requisite technical capability and sound financial position to bid for Works (as defined in the ITB) required to be undertaken for building the New admin. & Engg. Block (as defined in the ITB) including but not limited to construction activities required to be undertaken for building the New admin. & Engg. Block including but not limited to HVAC & CHILLER activities required for development of the Project (as defined in the ITB).

B. The Client is desirous of having provided and executed certain Works mentioned, enumerated or referred to in the Bidding Documents (as defined in the ITB).

C. The Contractor is the successful bidder in respect of the Works to be undertaken pursuant to the Tender issued by the Client.

D. In accordance with the process agreed in the Bidding Documents, the successful bidder will undertake the Works at the Site in accordance with the terms and conditions set out in this Agreement. Accordingly, the Parties have agreed to enter into this Agreement for undertaking the Works for HVAC & CHILLER of the New admin. & Engg. Block at the Site.

NOW THEREFORE THE PARTIES AGREE AS FOLLOWS:

1. **DEFINITIONS & INTERPRETATIONS**

1.1. **Definitions**

All capitalized terms used in this Agreement, but not defined herein shall have the meaning given to it in Clause 1 of the General Conditions of Contract ("**GCC**") which have been attached hereto as **Schedule A**.

The rules of interpretation as set forth in Clause 1 of the GCC shall apply *mutatis- mutandis* to this Agreement.

2. **SCOPE OF WORK**

The Works to be carried out by the Contractor, as part of its scope of work with regard to the HVAC & CHILLER of the New admin. & Engg. Block shall be as specified in Clause 2 of the GCC, Schedule I (*Scope of Works*) of the GCC (attached separately as detailed BOQ), and the Technical Specifications.

3. **CONTRACTOR PERFORMANCE BANK GUARANTEE**

The Contractor Performance Bank Guarantee to be submitted to the Client by the Contractor shall be as specified in Clause 3 of the GCC.

4. **[__] OF NEW ADMIN. & ENGG. BLOCK**

The HVAC & CHILLER of New admin. & Engg. Block by the Contractor shall be as specified in Clause 4 of the GCC.

5. **CONTRACTOR'S OBLIGATIONS**

The Contractor's Obligations shall be as specified in Clause 5 of the GCC.

6. **CLIENT'S OBLIGATIONS**

The Client's Obligations shall be as specified in Clause 6 of the GCC.

7. **TIME FOR COMMENCEMENT AND COMPLETION**

The time for Commencement and Completion of the Works shall be as specified in Clause 7 of the GCC.

8. **MATERIALS AND WORKMANSHIP**

The Materials and Workmanship to be provided by the Contractor shall be as specified in Clause 8 of the GCC.

9. **PERFORMANCE PARAMETERS**

The Performance Parameters to be conducted by the Contractor in the presence of Client in order to ensure the operation of the New admin. & Engg. Block shall be as specified in Clause 9 of the GCC.

10. **LIQUIDATED DAMAGES**

The Liquidated Damages to be paid by the Contractor shall be as specified in Clause 10 of the GCC.

11. **COMPLETION AND ACCEPTANCE OF WORKS**

The Completion and Acceptance of Works to the satisfaction of the Client shall be as specified in Clause 11 of the GCC.

12. **PROJECT MANAGER**

The obligations of the Project Manager shall be as specified in Clause 12 of the GCC.

13. **ARCHITECT**

The obligations of the Architect shall be as specified in Clause 13 of the GCC.

14. **DOCUMENTS**

The Documents to be provided by the Contractor shall be as specified in Clause 14 of the GCC.

15. **CONTRACTOR TO INFORM ITSELF FULLY**

The obligation of the Contractor to inform itself fully shall be as specified in Clause 15 of the GCC.

16. **SUB-CONTRACTORS**

The engagement of Sub-Contractors shall be as specified in Clause 16 of the GCC.

17. **TRANSFER OF OWNERSHIP**

The transfer of ownership of the New admin. & Engg. Block shall be as specified in Clause 17 of the GCC.

18. **REPRESENTATIONS AND WARRANTIES**

The representations and warranties of the Parties shall be as specified in Clause 18 of the GCC.

19. **CONTRACTOR'S WARRANTIES**

The Contractor's Warranties shall be as specified in Clause 19 of the GCC.

20. **INSURANCE**

The Insurance to be obtained by the Contractor shall be as specified in Clause 20 of the GCC.

21. **DEFECT LIABILITY PERIOD**

The Defect Liability Period shall be as specified in Clause 21 of the GCC.

22. **VARIATION AND CHANGE IN CONTRACT ELEMENTS**

The Variation and Change in Contract Elements shall be as specified in Clause 22 of the GCC.

23. **CONTRACT PRICE AND INVOICING**

The Contract Price and Invoicing shall be as specified in Clause 23 of the GCC.

24. **TERMS OF PAYMENT**

The Terms of Payment shall be as specified in Clause 24 of the GCC.

25. **SITE OFFICE, SECURITY AND FACILITIES**

The obligation of the Contractor with respect to the Site Office, Security and Facilities shall be as specified in Clause 25 of the GCC.

26. **SAFETY REQUIREMENTS**

The Safety Requirements to be adhered to by the Contractor shall be as specified in Clause 26 of the GCC.

27. **LIMITATION OF LIABILITY**

The Limitation of Liability shall be as specified in Clause 27 of the GCC.

28. **INDEMNITY**

The Indemnification and payment of indemnities shall be as specified in Clause 28 of the GCC.

29. **CONFIDENTIAL INFORMATION**

The obligations of the Parties with respect to the Confidential Information shall be as specified in Clause 29 of the GCC.

30. **INTELLECTUAL PROPERTY RIGHTS**

The ownership of the Intellectual Property Rights shall be as specified in Clause 30 of the GCC.

31. **FORCE MAJEURE**

The Force Majeure event shall be as specified in Clause 31 of the GCC.

32. **CHANGE IN LAW**

The occurrence of events comprising Change in Law shall be as specified in Clause 32 of the GCC.

33. **SUSPENSION**

The Suspension of Works shall be as specified in Clause 33 of the GCC.

34. **TERMINATION**

The right of Parties to terminate the Agreement shall be as specified in Clause 34 of the GCC.

35. **GOVERNING LAW AND DISPUTE RESOLUTION**

The Governing Law and Dispute Resolution mechanism shall be as specified in Clause 35 of the GCC.

36. **MISCELLANEOUS**

The miscellaneous provisions of the Agreement shall be as specified in Clause 36 of the GCC.

[signature page follows]

IN WITNESS WHEREOF the parties have executed this Contract as of the date first recorded above.

CLIENT

SHAKUNTALA EDUCATIONAL & WELFARE SOCIETY

_____

Name:
Title:

CONTRACTOR

[__]

_____

Name:
Title:

GALGOTIAS UNIVERSITY

GUARANTEE PROFORMA

GUARANTEE FOR CHILLER SYSTEM INSTALLATION

We hereby guarantee that the CHILLER System, which we have installed in the building described below:

Building -

Location -

Owner -

System description -

We confirm having checked / studied the building drawings, building orientation, location of plant rooms and service areas, construction details of glazing, walls, partitions, ceiling & roof and technical features & various constraints & parameters. We confirm having verified internal loads from the Architect / PMC/ Owners.

We confirm having calculated all the heat loads for all the areas for the three seasons and confirm the space loads and plant capacities are as per tender documents are correct.

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

WE ALSO HEREBY UNDERTAKE to test the entire installation in first SUMMER / MONSOON / WINTER season following the completion of the installation, to check and do every thing necessary to ensure that the specified indoor conditions in all spaces are maintained, that all water and air systems are properly balanced, that all controls are calibrated accurately, and that all units are functioning satisfactorily.

Date: SIGNATURE OF SUPPLIER / CONTRACTOR

SEAL:

Note: Any descripency found in the system, design & the schedule of quantities viz-a-viz owners requirement, need to be brought to the notice at the time of tendering process & alternate system to be suggested.

GALGOTIAS UNIVERSITY

GUARANTEE PROFORMA

GUARANTEE FOR HIGH & LOW SIDE HVAC SYSTEM AND BASEMENT VENTILATION & STAIRCASE, LIFTWELL & LIFT LOBBY PRESSURISATION & SMOKE VENTING ETC. SYSTEM INSTALLATION

We hereby guarantee for adequacy & correctness for the High & Low side HVAC System and Basement Ventilation & Staircase, Liftwell & Liftlobby Pressurisation & Smoke Venting etc . system, which we have installed in the building described below:

Building -

Location -

Owner -

System description -

We confirm having checked / studied the building drawings, building orientation, construction details of glazing, walls, partitions, ceiling & roof and technical features & various constraints & parameters. We confirm having verified internal loads from the Architect / PMC/ Owners.

We confirm having calculated all the heat loads for all the areas for the three seasons and confirm the space loads and plant capacities are as per tender documents.

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

WE ALSO HEREBY UNDERTAKE to test the entire installation in first SUMMER / MONSOON/ WINTER season following the completion of the installation, to check and do every thing necessary to ensure that the specified indoor conditions in all spaces are maintained, that all water and air systems are properly balanced, that all controls are calibrated accurately, and that all units are functioning satisfactorily.

WE ALSO HEREBY UNDERTAKE to test the entire installation of Basement Ventilation & Staircase, Liftwell & Liftlobby Pressurisation & Smoke Venting etc . system following the completion of the installation, to check and do every thing necessary to ensure the proper working of ventilation & pressurization system as per codes & standards and Fire NOC.

Contractor / Vendor to work out its own Summer / Monsoon / Winter AC heat load calculation to check & verify the AC heat loads & AC equipment selection / scheme.

Contractor / Vendor to highlight any changes / discrepancy found in its calculations & consultant's design/selection as per this tender while submitting the bid / Tender / Quotation and repeating the same process after receiving the order during the preparation of shop drawings and technical submittals but before ordering and installation of equipment / system.

For carrying out all the necessary design calculation, contractor / vendor to visit site / check / collect necessary data from Site / Client / PMC /Consultant.

Contractor/ Vendor to work out its own Basement ventilation, smoke venting & Staircase / Lift well / Lift Lobby pressurization calculation to check its suitability / adequacy as per latest 'NBC' of India & Fire safety norms / codes / fire NOC. Contractor to comment on any inadequacies & propose alternative solution.

Date: SIGNATURE OF SUPPLIER / CONTRACTOR

SEAL:

Note: Any descripency found in the system, design & the schedule of quantities viz-a-viz owners requirement, need to be brought to the notice at the time of tendering process & alternate system to be suggested.

GUARANTEE PROFORMA

GUARANTEE FOR BMS INSTALLATION

We hereby guarantee the year round BMS which we have installed in the Complex described below :

Building –

Location –

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

WE ALSO HEREBY UNDERTAKE to test the entire installation upon completion and ensure that all systems are functioning satisfactorily.

SIGNATURE OF TENDERER
For LOW VOLTAGE INSTALLATION

DATE :

SEAL