ANNEXURE A

RFP/HEN/2018/49- INSTALLATION OF AIR-CONDITIONING SYSTEM IN SABC HENLEY DATA CENTRE

GENERAL TECHNICAL SPECIFICATION

GENERAL TECHNICAL SPECIFCATION FOR AIR CONDITIONING INSTALLATION

INDEX

1 SCOPE

1.1 This General Specification describes the usual material required for Air Conditioning and Control installations and the general methods of constructing and installing the various components and equipment associated therewith.

1.2 This General Specification forms a supplement to the Detailed Specification, Drawings and Equipment Schedules for a particular subcontract. Where the *Detailed Specification* (described later) and/or the drawings differ from this General Specification, and not clarified by the engineer the most stringent requirement of the two documents shall prevail.

2 GENERAL SPECIFICATIONS & REQUIREMENTS

 In the following Specification the term "Contractor" shall mean the legal entity responsible for carrying out all the necessary works for the HVAC installation and the term 'Builder' shall mean the Main Contractor, the term ‘Employer’ shall mean Client or Owner.

2.1 GENERAL REQUIREMENTS

1 The tender shall be signed by the Tenderer’s authorised signatory and shall comply with all the requirements and conditions of the tender document. The tender shall be free from any qualification and any qualification submitted shall be null and void and deemed to be as in original document. The contractor shall carryout and complete the works in conformity with all the instructions and directions of the Engineer. The contractor shall include everything necessary for proper execution of works and to the complete satisfaction of the Engineer. No claim arising out of errors in the tender document shall be accepted.

2 Tenderer shall bear all costs for site visits, want of all information for preparation and submission of tender. Employer reserves the right to reject any/ all tenders without assigning any reason.

3 Tenderer shall raise written query for any clarification that shall be answered, if possible through addendums/ circulars. All such addendums/ circulars shall form part of the contract agreement.

4 The tenderer shall submit with their tender, detailed method statement for each activity, works programme, site organisation chart with CVs, manpower histogram, list of sub-contractors to be engaged, list of plant and machinery, list of similar projects executed in last 3 years, source of local and imported materials, present project involvement, financial standing and any other information/ details required by the Engineer.

5 Any item of works shown on drawings but not described in specifications, bill of quantities, schedule or vice versa shall be deemed to be allowed by the contractor. In cases where all the necessary information is not supplied by the tenderer, then the Engineer's decision shall be final.

6 The tenderer shall obtain all necessary and latest government and statutory permits for their works, comply with all local and labour laws. The entire installation shall comply fully with all relevant requirements of governmental and local authorities and the equipment provided for the installation shall comply in all respects.

7 Alternative equipment, materials or apparatus from those that are noted or required on the drawings and/or in the Specifications, may only be offered and supplied on the written approval of such equipment, material or apparatus by the Engineer.

8 All workmanship and materials used in the installation shall be of the highest quality and, where not fully covered by this Specification, shall conform to the best modern practice, as determined by the Engineer. It is the sub-contractor’s responsibility to bring such cases to the Engineer’s attention timeously. All necessary insurances shall be taken out by the contractor for their works. Contractor shall indemnify the Employer from any claims arising out of infringement of any patent rights/ royalties.

9 The contractor shall clean and clear up the site after practical completion of works, to the satisfaction of the Engineer.

10 In case of bad workmanship, delay of works / uncompleted works and /or abandonment of works and failure to comply with instructions, the Employer reserves the right to pay other persons to complete the works to their satisfaction and recover such amount from any monies due or to become due. No extension of time shall be permitted under any circumstances other than Force Majeure or stated by the Client.

11 “Fix”/”Install” shall mean but not be limited to check, receive, transport, load and unload, safe storage, hoist or rigging into position, assemble and position, testing and commissioning etc. to ensure a complete and fully working system in accordance with manufacturer’s requirements.

12 Where there is a variance between the Specification and the drawings, such differences shall be referred to the Engineer before tender submission who shall issue written clarifications whenever possible.

13 The importance of reading the Specification in its entirety is emphasized. Some items/operations are included in the Specification or Bill of Quantities, but may not have been shown on drawings. No claim will be entertained for lack of knowledge or non-awareness of items contained within this document.

14 Should any portion of the Works which would reasonably and obviously be inferred as necessary for the installation as a whole not be expressly specified, the Contractor shall provide and execute such work as part of the contract and shall not be entitled to any extra payment of the account.

15 Should the Engineer discover on the works any materials other than those approved, he may order their removal from the site, including the demolition of any works already built with these materials at no cost to the Employer.

2.2. CONTRACTOR REQUIREMENTS

1. The Contractor shall provide everything necessary for the full completion of the works and work shall be executed in a workmanlike manner and in accordance with the approved form of modern practice.

2. The Contractor must inspect the site and will be deemed to have satisfied himself as to the accessibility thereof, the local conditions, the facilities for obtaining the materials or article referred to, the supply of and conditions affecting labour, the carriage, carting, unloading, storage and safe custody of materials, tackle and tools necessary, the supply of power, light and water, drainage and generally to have obtained his own information on all matters affecting the execution of the works and the prices tendered thereof.

3. The Contractor must provide, at his own cost and charge, the whole of the materials and transport of same, together with all labour, tools implements, ladders, site offices, stores, workshops and everything necessary for the due performance of the works specified.

4. The Contractor shall cover-up and protect the various works and portions thereof from all damage due to unconsidered or rough treatment, inclement weather, dust, grit, or injury in other ways and will make good any damage or deterioration that may occur free of charge. All bright parts of fittings shall be covered with transparent polyethylene sheeting and shall be cleaned and polished before being handed over.

5. Contractor shall be responsible for site security and safety requirements related to manpower, material, plant and machinery, offices, temporary facilities etc. The contractor shall take all necessary safety precautions to prevent the possibility of accidents that may be caused mechanically, electrically or otherwise during the course of the works. The works shall include the provision and fixing of detachable guards of approved designed to cover all moving machine parts wherever they may be located and whether they are intended to be permanent or temporary and in such manner as to comply with the appropriate statutory requirements. It shall also include such step-down transformers as to be used for portable electrical tools and the Contractor's workforce shall be provided with all necessary safety gear on site for any works.

6. The Contractor must confine his workmen, materials and plant to the portion of the site as directed by the Builder and carry out his work at such times as will conform to the general progress schedule of the Builder and thereby enable the Builder to complete his work within the programme.

7. The contractor shall employ only competent and skilled work force and technical staff for execution of works. The Engineer may interview the personnel to assess their skills and competence.

8. The Engineer reserves the right to dismiss instantly from the work any workman employed by the contractor who may misconduct himself on the site or who may be incompetent in the opinion of the Engineer.

9. The direction of the Engineer as to the manner of executing the various works and the proper mode of conducting them shall, at all times, be strictly adhered to and the work completed to the satisfaction of the Engineer.

10. The Contractor and his employees shall be bound to conform to the rules and regulations in force on the site for the proper conduct of the work and must avoid

any complications that might cause disputes or strikes amongst his own or any other workmen.

11. The Contractor shall maintain and protect public property and the property of the Telecommunications, Water and Electricity Authorities and similar undertakings and make good or pay for all damage thereto.

12. Periodical meetings will be held at the site as and when required by the Builder or Engineer and the Contractor shall arrange to have an accredited representative present at each of these meetings until the contract is completed.

13. The Contractor shall submit a written report at least 48 hours before the meeting to the Engineer outlining the progress of the work, information status, queries and work completed to date.

14. The contractor shall furnish weekly report of manpower engaged at site along with the plant and machinery for timely and proper execution of works. The Engineer reserves the right to instruct the contractor to increase the resources at site to expedite the works.

15. Contractor shall submit site organisation chart and manpower histogram prior to start of works for Engineer approval.

16. Weekly site progress meetings may be scheduled at site, which should be attended by contractor senior personnel. The contractor shall come prepared with all the updated information related to planning and progress of works which shall incorporate but not be limited to drawing schedule, drawing production programme, material approvals, material delivery, installation, testing and commissioning, samples, method statements, manpower histogram etc. The works programme should be specific to each task and area, covering all aspects with the required number of skilled work force to complete the task.

17. A Quality assurance system to execute the works shall be submitted for review and comment by the Engineer.

18. The Contractor shall keep at least one competent agent in charge of the works, who shall be considered to be the duly accredited representative of the Contractor, empowered to take instructions from the Engineer and to execute same and who must be in attendance at the premises until the whole of the works

have been completed and passed by the Engineer and shall instruct and give all information regarding the plant and/or equipment to the Engineer.

19. In the event of any damage to materials and/or apparatus when in transit to the site, or by the workmen employed by other parties, the Contractor shall be entirely responsible for arranging the necessary compensation for such damages between the parties concerned and shall remedy such damage without charge to the Employer. The Contractor shall be responsible, until installation is taken over by the Employer, for the protection of all materials and replace at his own expense any article damaged by him, however such damage may occur. The Engineer will not participate in any discussion or proceedings concerning the fault or liability of any party due to such damage.

20. The Contractor shall set out the works and be responsible for the accuracy of same and the position of all plant and/or equipment shall be approved by the Engineer. The Contractor shall pay particular attention to the method of fixing all conduit boxes, switch boxes and socket outlet boxes, etc., so that these shall, when completed, be in an exact position relative to the finished plaster to permit all the cover plates being fixed accurately. The Contractor, at his own cost, shall amend any errors arising from his own inaccurate setting out and alignment, unless the Engineer shall otherwise direct.

21. The contractor shall prepare the working drawings as detailed elsewhere taking into account all the design details, equipment details, specialist item drawings, service and maintenance requirements, co-ordination with all the services, architectural and civil requirements. The drawing shall be coloured with different colours for each services. The drawings shall be prepared in CAD software. The contractor shall carryout all necessary site survey for correctness of drawings. The approval of drawing by Engineer shall not relieve the contractor of his contractual obligations as the approval is only general and not intended to serve as a detailed check. As built drawings shall be prepared after installation and submitted for Engineer approval. Drawings shall be prepared in accordance with latest revision and comments. All submissions shall be reviewed by Engineer and returned with appropriate status / comments.

22. The Contractor shall allow reasonable time (+/- 24 hours) for the Engineer to make arrangements for inspection and give permission for dispatch to the site.

Delay to the Works arising from late notification of such details will not be accepted as reason for delay in completion of the works.

23. The Contractor shall be fully responsible for ensuring that all plant and materials supplied under this contract are suitable for use under local climatic conditions.

24. The warranty period (defects liability period) shall commence from the date of issue of the completion certificate and continue for a minimum period of 12 months or as stipulated in the Detailed Specification or Bill of Quantities.

25. It remains the Contractor's responsibility to obtain all the relevant local authority approvals and clearances for occupation of the building before handover e.g. Civil Defense approval, electrical installation compliance etc.

26. The works shall not be considered complete until a final certificate of completion have been issued by the Engineer stating that the works and testing have been completed by the Contractor as per the contractual obligations and that the site has been satisfactorily cleared.

27. The materials and works shall be in accordance with the following standards and codes of practice where applicable:

- British Standard Specification (BS) and Codes Of Practice (BSCP)
- American Society of Heating Refrigeration & Air Conditioning Engineers.
- Sheet Metal Air Conditioning Contractors National Association SMACNA.
- Water Bylaws
- Local Building Regulations
- Local By-Laws and/or Regulations
- Health & Safety Work Acts
- Equipment & Supplier Specifications.
- Government Specifications.
- NFPA 92A

28. The Contractor shall keep one copy of each relevant standard on site at all times and is responsible for the subsequent updating when a standard is superseded. The Contractor shall give notice in writing of any deviation from these practices

and shall provide a copy of the standards or codes of practices he wishes to adopt at the time of tender.

2.3. MATERIAL SUBMISSIONS AND APPROVAL

1 Material and drawings shall be submitted for Engineer approval ***strictly in accordance with the Material Submittal Guidelines*** (refer clause somewhere else in document) with all details, but not limited to catalogues, shop drawings, technical literature, technical calculations, samples, compliance statement etc. No material shall be ordered without written approval of the Engineer.

2 Where approval of products or materials is specified, the Contractor shall submit samples or other evidence of suitability. The Contractor shall not confirm orders or use materials until approval has been obtained.

3 Approved samples shall be retained on site for comparison with products and materials used in the works and shall only be removed when no longer required.

4 Where samples of finished work are specified, the Contractor shall obtain approval of stated characteristic(s) before proceeding with the Works and shall retain approved samples on site for comparison with the works. Samples which are not part of the finished works shall be removed when no longer required.

5 Submission of samples shall be made at such times as to allow sufficient time for approval to be given and on no account will delays to the work be accepted where caused by failure in obtaining approval by the Engineer.

6 Where a choice of manufacturer or source of supply is allowed for any particular product or material, the whole quantity required to complete the work must be of the same type, manufacturer and/or source. Do not change without approval.

7 Before ordering materials of any description for the permanent Works, the Contractor shall if required by the Engineer submit to him for approval the names and addresses of the Manufacturers and Suppliers proposed and source of material, and shall afterwards provide copy of the orders given by the Contractor for the materials, if and when asked for.

8 All major equipment shall be inspected at manufacturers work prior to delivery for their performance testing, if asked for in the equipment schedule. The expenses towards the inspection for maximum 2 persons shall be borne by the contractor.

9 In certain instances specific makes of plant are necessitated to suit the layout of the site, building construction, internal layouts, etc. and no alternative make must be included by the Contractor in his tender unless he obtains special permission from the Engineer in writing before submitting his tender. Permission, however, will only be given if the Contractor can satisfy the Engineer that the alternative make of equipment can be satisfactorily accommodated.

10 All materials shall be new unless otherwise stated. Any materials not accepted by the Engineer shall be removed and replaced by the Contractor at his own expense.

2.4. OPERATING AND MAINTENANCE MANUALS & TRAINING

2.4.1.1. AS-BUILT DRAWINGS

1 The Sub-Contractor shall at all times keep a set of updated as-built drawings on site. Twelve (12) weeks prior to the Taking Over Certificate for the whole of the Works, the Sub-Contractor shall produce and provide the Principal Agent with a draft set of as-built drawings consisting of one paper print per drawing. These drawings shall consist of the following:

(a) Scaled plan layouts of all pipe, duct and similar installations (1: 100 scale);

(b) Scaled plan, sections and elevation drawings of all plant layouts (1: 100 scale);

(c) Detailed electrical panel wiring diagrams and panel layouts;

(d) Manufactured equipment drawings;

(e) Electrical installation drawings.

(f) A general description, illustration and flow diagram of the whole installation.

2 The drawings shall be detailed in such a manner to enable the Employers maintenance staff to maintain, dismantle, reassemble and adjust all items, parts and equipment of the installation.

3 Prior to issue of the Taking over Certificate for the whole of the Works, a register of the entire as-built drawings package must be provided to the Principal Agent in an electronic PDF CD format and a hardcopy set of lever arch files.

4 Prior to issue of the Taking Over Certificate for the whole of the Works, the Sub - Contractor shall produce and provide the Principal Agent with a set of as-built drawings consisting of one paper print as well as an electronic format CD (“AutoCAD” 2014) set of drawings .These drawings shall consist of items (a) to (f) above. The paper prints must be handed over in a suitable drawing hanging cabinet.

5 The Taking over Certificate for the whole of the Works shall only be furnished once the above has been submitted to and approved by the Principal Agent.

2.4.1.2. OPERATING AND MAINTENANCE MANUALS

1 Prior to Practical Completion for the whole of the Works, the Sub-Contractor shall produce and provide one set of draft Operating and Maintenance Manuals (in hard copy lever arch files) to the Engineer for approval. These manuals shall be structured to include at least the following:

(a) **System description**

Complete system description and the working of the plant.

(b) **Commissioning data**

Complete commissioning, testing and inspection data of systems and equipment, including all start up dates and detailed operating and servicing logs. All Sub- Contractors staff which are testing, operating and servicing the installation must be suitably qualified and experienced, and all relevant CV's to be forwarded to the Principal Agent for approval.

(c) **Operating data**

i. Systems and equipment running check list and frequency of servicing required;

ii. Safety precautions to be implemented

iii. Operator's duties and logging required

iv. Lubricating oils and service instructions

(d) **Mechanical equipment**

i. Description of all major items with the make, model number, names, addresses and telephone numbers of the suppliers, manufacturer or their agents;

ii. Design capacities of all equipment, including selection parameters, selection curves, capacity tables, etc.;

iii. Manufacturer's brochures and pamphlets;

iv. Schedule of spares with part numbers recommended to be held as stock.

(e) **Maintenance instructions**

(i) Schedule of maintenance particulars, frequency of services and replacements;

(ii) Trouble-shooting guide;

(iii) Part number of all replacement items and spares;

(iv) Capacity curves of pumps;

(v) Serial numbers of all items of equipment.

(f) **Electrical equipment**

i. Schedule of equipment, indicating manufacturer, type, model number, capacity and addresses and telephone numbers of suppliers;

ii. Maintenance instructions;

iii. Manufacturer's brochures and pamphlets;

iv. Complete as-built circuit diagrams and diagrammatic representation of inter-connections of all electrical equipment.

(g) **Instrumentation and control**

i. Description of each control system;

ii. Schedule of control equipment indicating manufacturer, type, model number, capacity and addresses and telephone numbers of suppliers;

iii. Maintenance instructions;

iv. Manufacturer's brochures and pamphlets.

(h) **Drawings**

i. Wiring diagrams framed behind glass shall be mounted adjacent to each relevant control panel.

2 Prior to issue of the Taking over Certificate for the whole of the Works, a register of the entire Operating and Maintenance Manuals package must be provided to the Principal Agent in an electronic PDF CD format and a hardcopy set of lever arch files.

3 Prior to issue of the Taking over Certificate for the whole of the Works, the Sub-Contractor shall produce and provide the Principal Agent with a set of Operating and Maintenance Manuals consisting of one electronic PDF format CD as well as a set of Lever Arch file paper copies. These Manuals shall at least consist of items (a) to (h) above.

4 The Taking over Certificate for the whole of the Works shall only be furnished once the above has been submitted to and approved by the Principal Agent.

2.4.1.3. TRAINING AND OPERATION OF INSTALLATION AND EQUIPMENT

1 The Sub-Contractor shall be responsible for providing onsite training to the operating and maintenance personnel. The Sub-Contractor shall facilitate the training in conjunction with the Principal Agent or Engineer as follows:

i. Prior to issue of Practical Completion for the whole of the Works, the Sub-Contractor shall;-

Produce and provide the Engineer with a detailed training schedule.

Commence a four (4) week multi-media classroom training period.

2 The training of the maintenance and operating personnel is to include the following aspects:

(a) Awareness of safety, health and personal hygiene in terms of the requirements of the Relevant Life Safety Code;

(b) Functioning of the installation, including all its systems, services, parts of buildings and infrastructure;

(c) All specific tasks related to routine preventative maintenance;

(d) Interpretation and understanding of Operating and Maintenance Manuals;

(e) Repair/reconditioning and installation/construction of equipment and materials forming part of an installation;

(f) Equipment and component recognition;

(g) How to operate the equipment including the following:

i. Starting the equipment;

ii. Manual and automatic controlling

iii. Shut-down and isolating of equipment and systems;

iv. Cleaning of equipment.

h) Emergency procedures to be followed in the case of breakages, system faults, etc.

(i) Safety precautions to be followed and implemented.

(j) The identification, reporting and recording of faults and operation of equipment.

(k) The logging of equipment operation, readings and settings.

3 On completion of the training of the maintenance personnel, the Sub-Contractor shall evaluate each of the personnel by means of an approved examination.

2.4.1.4. COLOUR CODING AND INDEXING REFERENCES

1 The Sub-Contractor shall apply colour coding and indexing formats to the As Built Drawings and the Operating and Maintenance Manuals in accordance with the Principal Agents requirements.

2.5. COMMISSIONING AND TESTING - PRELIMINARY TESTS ON COMPLETION

1 Full commissioning must be done prior to Practical Completion. Failing to do so the consultant will not grant PC.

2 Proper commissioning of all the HVAC system is crucial to ensure the correct operation of the HVAC system.

3 It is the HVAC Contractors responsibility to hand over a commissioned system, with the relevant documentation

a) Construction Installation (Pre-commissioning) Checklists.

b) Functional Performance Checklists.

4 Commissioning shall be done using the following CIBSE codes :

a) CIBSE Code A – Air Systems

b) CIBSE Code W – Water Systems

c) CIBSE Code B – Boilers

d) CIBSE Code C – Automatic Controls

e) CIBSE Code M – Commissioning Management

5 Following completion of the HVAC and Controls Works, or any portion of the HVAC and Controls Works as specified or directed by the Engineer, the Sub-contractor shall balance, set and test the HVAC and Controls Works or portion of the HVAC and Controls Works, in accordance with the following requirements, to establish the capacity and satisfactory performance of the Plant.

6 All balancing, setting and testing shall be done by the Sub-contractor entirely at his own expense. The Sub-contractor shall provide all facilities and apparatus for the testing of the Plant and shall carry out such tests as may be necessary to satisfy the Engineer that the Plant meets with the requirements of the Specifications.

7 The Sub-contractor shall also carry out or attend upon all tests required by Government and Local Authorities who have jurisdiction over the Works and shall obtain all necessary certificates of approval and acceptance and provide the Engineer with triplicate copies of all such certificates prior to or at such time as, providing the Engineer with copies of his 'Preliminary Test' report.

8 All test instruments shall be checked for accuracy by the manufacturers, suppliers or approved laboratory and certified copies of certificates showing the degree of accuracy shall be supplied to the Engineer together with the Preliminary Test' reports.

9 Gauges, thermometers, ammeters and other instruments specified as part of the permanent Plant may be used for test purposes providing that the Sub-contractor ensures that all such instruments are accurately calibrated. The Sub-contractor shall check the accuracy and calibrate all such instruments against laboratory tested instruments.

10 The Sub-contractor shall when required, provide the Engineer with equipment selection and performance data for all major items of plant, such as Air Conditioning Units, Air Handling Units, Cooling Towers, Pumps, Fans and Sound Attenuators.

11 The Sub-contractor shall keep full and proper written records of all tests conducted and commissioning information, such data to be properly indexed and clearly set down to form part of the Operating and Maintenance manuals called for in the Specification.

12 The Engineer reserves the right to inspect any item of equipment during manufacture or before delivery to site. The Sub-contractor shall make available any item for such inspection.

13 Electrical switch panels shall be inspected by the Engineer at their place of manufacture, prior to delivery to Site. At such inspection and testing, the Sub-contractor shall demonstrate the functioning of the switch panel to the Engineer. Any defects in materials, finishes and operation of the switch panels shall be corrected at their place of manufacture prior to delivery to site.

14 The Sub-contractor shall, on handing over the installation or any portion thereof, to the Engineer, also provide the necessary certificates as proof of having conducted a satisfactory electrical test to the requirements of the electricity supply authority, such certificate emanating from such authority and permitting full use to be made of the installation without the need for further tests.

15 The Sub-contractor shall properly test and call for inspection by the Engineer, any work which is to be covered, concealed, built-in, otherwise closed up or rendered inaccessible, before such closing up takes place. The Engineer may require any work of this nature which he has not been called on to inspect before closing up, to be uncovered or made accessible entirely at the Sub-contractor's expense, making good included.

16 Prior to the 'Final Tests', to be attended by the Engineer, the Sub-contractor shall balance, set and test the following to establish the capacity and performance of the Plant. All such 'Preliminary Tests' shall be recorded by the Sub-contractor who shall provide the Engineer with three typed copies of all test recordings which shall set out procedure, data and instrument readings obtained as compared with the specified capacities and the manufacturer's name plate ratings where applicable. Such preliminary test reports shall be accompanied by one preliminary draft set of Operating and Maintenance Instructions prepared in accordance with the requirements as detailed herein.

17 On receipt of an acceptable preliminary test report and draft copy of the Preliminary Operating and Maintenance Instructions the Engineer shall advise the Sub-contractor

in writing so that he may arrange for the "Final Test" and issue of the Acceptance Certificate/s.

THE 'PRELIMINARY TESTS' SHALL INCLUDE THE FOLLOWING:

18 Drains shall be tested for proper functioning by pouring water down them at a rate of at least four times normal drainage.

19 Field assembled refrigerant piping and apparatus shall be tested with dry carbon dioxide or nitrogen plus a small amount of refrigerant. Test procedures shall be in accordance with the latest edition of the American Standard Safety Code for Mechanical Refrigeration. Leaks in pipe joints shall be corrected by remaking the joints. Caulking will not be permitted. The vacuum test shall follow the pressure test.

20 Charging of the equipment with refrigerant shall follow the vacuum test as closely as is practicable to minimise the possibility of air or moisture being returned to the system. After charging and prior to capacity tests, joints in refrigerant piping and apparatus shall be checked with a halide torch or other equally sensitive leak detector. If leaks are found, the system shall be pumped down and the leaks corrected.

21 Capacities of Air Conditioning Units, Fans and other equipment shall be determined by operating tests of not less than four hours duration, after stable conditions have been established. Test procedures shall be in accordance with applicable portions of **ASME** and other recognised test codes as far as field conditions permit. Capacities shall be based on temperatures and air quantities measured during such tests.

22 Temperature differences required for determining capacities shall be measured by thermometers having graduations that permit interpolations having an accuracy of ±0,5 °C.

23 Air quantities may be measured by Pitot tube, anemometer or velometer, depending on the velocity and other conditions of flow.

24 Check alignment of all equipment drives prior to setting into operation.

25 Air systems shall be checked for obstructions and balanced to provide the required air quantities at each outlet without objectionable noise and draughts and so that the velocity of the air is relatively uniform over the area of the outlet.

26 Velocity meters may be used to test all outlets and for duct velocities up to 1,5 m/s, above which velocities shall be measured with Pitot tubes. Properly capped openings shall be provided in ducting as required. Final setting of all volume adjusting devices shall be permanently marked.

27 Should it be necessary to re-balance any air system due to partitioning or repartitioning of the conditioned space after the specified conditions have been

obtained and accepted by the Engineer in writing, then such re-balancing shall be carried out as an extra to the Sub-contract and shall be authorised, by the issue of a 'Variation Order', by the Engineer.

28 All automatic controls and safety devices shall be checked for correct performance and satisfactory operation and set to the respective settings required.

29 All electrical switch panels shall be checked for the correct functioning of all components and electrical interlocks and all time clocks, time delay relays and automatic control devices shall be set for their correct function.

30 The full load running current of all electrically operated equipment shall be recorded and compared with the manufacturer's name plate ratings, which shall be recorded, together with any other relevant data stamped on the name plates. All overload protection devices shall be set to the correct values, which shall be recorded.

31 The Sub-contractor shall ensure that the plants operate satisfactorily and uninterrupted for a period of 7 days prior to the final acceptance by the Engineer. Evidence of this, for air conditioning systems, shall be given in the form of a 24 hour long continuous recordings of temperature and humidity, which recording shall cover at least 50% of the areas handled by any one plant and shall be handed over to the Engineer prior to inviting him to the Final tests and acceptance of the completed installation.

32 The original recorded graphs shall be supplied to the Engineer and the Sub-contractor shall also obtain and provide the Engineer with the daily maximum dry and wet bulb temperature readings recorded in the area on the same days as the inside conditions are recorded. Such information may be obtained from local weather stations.

2.6. COMPLIANCE AND REGULATIONS

1 The installation shall be erected and carried out in compliance with:

- NFPA 54
- ASME 31.8
- PD 80.10
- IEC 60298
- The Code of Practice for the Wiring of Premises (SANS 10142) where applicable and as amended.
- The Occupational Health and Safety Act (Act No 85 of 1993) as amended.

- The National Building Regulations and Building Standards Act and SANS 10400 and XA

2 This Specification covers wiring systems to the conventional type in which continuous metal conduit of circular cross section is used. Under normal circumstances no electrical cable or control cable shall be installed if not in conduit or approved flexible conduit or on a cable tray. Written approval for any deviation from this will be obtained for each case from the Engineer prior to the installation therefore. Should the Engineer permit or specify the use of innovative wiring systems such as surface mounted mini-trunking with removable covers, pre-wired multi-core conduit, T&E (twin and earth) cable or any other authorised innovative wiring system, such an installation shall comply with SANS 10142, as amended.

3 It shall be assumed that the Contractor is fully conversant with the above regulations and requirements. Should any regulation, requirement or by-law which contradicts the requirements of this Specification apply or become applicable during erection of the installation (and is necessary to complete the installation satisfactorily), such regulation, requirement or by-law shall overrule the requirements of this document and the Contractor shall immediately inform Engineer of such a contradiction. Under no circumstances shall the Contractor carry out any variations to the installation in terms of such contradiction without obtaining the written permission to do so from the Engineer.

4 The Contractor shall indemnify ’client’ against any losses, costs or expenditures as well as culpability which may arise as result of Contractor’s negligence in complying with the requirements of the above regulations, requirements, by-laws and standards. The ’client’ will entertain no claims for extra costs in respect of failure by the Contractor to comply with any of the above regulations, requirements, by-laws and standards.

5 The Contractor shall appoint a Responsible / Competent Person in terms of the requirements of the Occupational Health and Safety Act to take all responsibility for the compliance with the Act of any of their staff, labour and subcontractors and all installations and equipment operated and plant installed by the Contractor. The Contractor (or the person authorised to tender) shall, if such a person is not appointed, personally take these responsibilities upon themselves. The Contractor shall indemnify the ’client’ and any of its employees against any culpability arising from any action or negligence on their behalf in this regard pertaining to the site of the Contract and its content or improvements of any nature.

2.7. DRAWINGS

2.7.1.1. TENDER DRAWINGS

1 The Drawings accompanying this Specification as numbered elsewhere of these documents shall be deemed to indicate the general layout and requirements only and are not Shop Drawings.

2 The Engineer shall provide the successful Sub-Contractor, free of charge, with a set of Specification Documents including all Tender Drawings

3 The Sub-Contractor shall ensure that he is in possession of all information required for the installation of the Works and shall, if necessary, obtain copies of all relevant drawings from the Architect and Structural Engineer so named in the documentation.

2.7.1.2. BUILDER'S WORK DRAWINGS

1 All Builders' Work and work to be carried out by others in accordance with the Specification has been indicated on the Tender Drawings. The Subcontractor shall check, approve, add to or alter such drawings as may be necessary to suit the Plant offered by him, and accepted by the Engineer, within ONE WEEK from date of receipt of Construction Drawings from the Engineer and shall submit to the Engineer in duplicate any revision which shall be made to such Drawings.

2 Such Builder's Work Drawings shall indicate the location and extent of all foundations, bases, openings, timber frames and all other Builder's Work and the capacities and/or dimensions of all electrical and water supply points, the method of terminating such supplies and the position of the connection points, the position and dimensions for all water drainage connections and any other work to be provided by others for the Works, as detailed in these Specifications.

3 The Drawings shall be drawn to scale and in sufficient detail to enable the Builder to execute the work without any misunderstanding.

4 Within one week after receiving such Drawings, the Engineer shall signify his approval, or otherwise, and one signed copy of each approved Drawing shall be returned to the sub-Contractor.

5 When approved, the following number of copies of each such Drawing shall be delivered to each of the following:

- Main Contractor 1 copy

- Architect 1 copy
- HVAC Consultant 1 copy

2.7.1.3. SHOP DRAWINGS

1 The sub-Contractor shall submit to the Engineer, for approval within TWO WEEKS duplicate copies of all Shop Drawings as required for the manufacture and installation of the Works or as the Engineer may reasonably require.

2 All Shop Drawings for work outside of plantrooms shall be drawn to a scale of not smaller than one in one hundred and all Drawings of work within plantrooms shall be drawn to a scale of not smaller than one in fifty. All details shall be drawn to a scale to show the detail required.

3 Within one week after receiving such Drawings, the Engineer shall signify his approval, or otherwise, in writing and one signed copy of each approved Drawing shall be returned to the sub-Contractor.

4 The sub-Contractor shall not, unless otherwise directed by the Engineer, in writing, commence with any work prior to the approval of the relative Shop Drawings. Work installed prior to the approval of Shop Drawings shall be liable to rejection by the Engineer and removal and/or replacement by the sub-Contractor, at his cost, if it is considered by the Engineer to deviate from the Specification.

5 The sub-Contractor shall also supply copies of all approved Drawings in accordance with the requirements of Clause 39 of Part Ten (Operating and Maintenance Instructions) of the Specification.

6 Drawings approved as above described shall not be departed from except as authorized by the Engineer.

7 The Engineer shall have the right at all reasonable times, to inspect at the factory of the sub-Contractor, all Drawings of any portion of the Works.

2.7.1.4. MISTAKES IN DRAWINGS

1 Any expense resulting from an error or omission in or from delay in delivery of the drawings, shall be borne by the Subcontractor.

2 The sub-Contractor shall be responsible for any discrepancies, errors, or omissions in the drawings and other particulars supplied by him, whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions are not due to inaccurate information or particulars furnished in writing to the sub-Contractor by the Engineer or the Architect. The Employer shall be responsible for drawings and information supplied in writing by the Engineer or the Architect and for the details of special work by either of them.

2.8 EQUIPMENT COLOUR CODING AND INDEXING

REFERENCES SABS – PAINT CODES TO BE KEPT ON FILE PLANT ITEM

PLANT ITEM	BASIC COLOUR	COLOUR CODE INDICATOR	
		1 Band	2 Bands
Chilled water system			
Primary chilled water pumps	Oriental Blue F22	-	-
Secondary chilled water pumps	Oriental Blue F22	-	-
Chilled water expansion tank	Oriental Blue F22	-	-
Primary chilled water supply	Brilliant Green H10	Oriental Blue F22	-
Primary chilled water return	Brilliant Green H10	Oriental Blue F22	-
Secondary chilled water supply	Brilliant Green H10	Oriental Blue F22	Dark Violet F06
Secondary chilled water return	Brilliant Green H10	Oriental Blue F22	Dark Violet F06
Condenser water system			
Condenser water pumps	Oriental Blue F22		
Condenser water supply	Brilliant Green H10	Golden Yellow B49	Flag Orange B20
Condenser water return	Brilliant Green H10	Golden Yellow B49	Flag Orange B20
Built-up air handling plants			
Air handling units	Ice Blue F76		
Supply air fans	Strong Blue F11	-	-
Exhaust air fans	Mid Grey G25	-	-
		-	-
General pipe services			
Compressed air mains	Arctic Blue F28	Salmon Pink A40	
Refrigeration suction	Middle Brow B13	-	-
Refrigeration hot gas	Middle Brow B13	Poppy Red A14	-
Refrigeration liquid	Middle Brow B13	Golden Yellow B49	-

Uni-strut or conduit casings for control air mains (other than copper)	Cloud Grey F48	-	
Drain pipes	Black	-	-
Blowdown pipes from boilers	Heat resistant	-	-
		-	-
Pump and fan guards	Signal Red A11		
Pipe hangers and brackets	Mid Grey G25	-	-
Elec. Duct heaters in plantroom	Signal Red A11		-
Cable trays in plantrooms	Light Orange B26	-	-

COLOUR CODING FOR SYMBOLS ON DUCTWORK

Duct/Air Type	**Colour of Symbol**	**Symbol Colour**	**Duct Background Colour**
Cold air supply	Strong Blue	F11	Arctic Blue F28
Foul air	Middle Brown	B07	Biscuit B64
Exhausted/extracted/re-circulated air	Mid-Grey	G25	Mountain Mist G57
	Grass Green	H14	Pastel Green H65
Outside air	Canary yellow	C61	Pastel Yellow C75
Warm air Conditioned air	Poppy Red & Strong Blue	A14 and F11	Ice Blue F76

On completion of the installation the Sub-contractor shall clean all equipment properly, remove all superfluous materials from the site, make good black granolithic finished equipment bases with black concrete paint, sweep out Plant rooms and make the Plant completely presentable before calling upon the Engineers to accept the plant after completion of the 'Preliminary Tests'.

2.9 LABELLING AND IDENTIFICATION

1 All equipment shall be labelled and identified using white Traffolite labels having 10mm high black lettering engraved on them; where two similar items exist, they shall additionally be numbered for clarity in identification, and Labels shall be neatly bolted to the equipment with brass fasteners.

2 Belt guards and items of plant containing belt driven equipment shall be fitted with a label stating the number of and the size of the belts for each V-belt drive. The labels shall be of the same type and dimensions and shall be fixed as specified above for all equipment.

3 Designate and identify each automatic control device such as 3-way valve, thermostat, damper motor etc., and fit to each a white Traffolite label having 5mm high black lettering, the label to be bolted to equipment with brass fasteners. Prepare a complete control Diagram of the installation and label with relevant designations mentioned above, all to form part of plant operating instructions which are later mentioned herein.

4 Label pipes with directional arrow neatly stenciled onto finished pipework or in the form of a durable proprietary transfer. Arrows shall be at not more than 5 meter

intervals and not less than 100mm long, of good colour contrast to equipment colour background.

5 Identify all Plant rooms as 'Air Conditioning' or 'Air Handling Plant Room' with 5mm thick engraved P.V.C. sheet notices having 25mm high black lettering on a white background.

6 Provide and install all necessary notices required in terms of 'Governmental and Local Authorities' laws, such as "No Entry to Unauthorised Persons", at all Plant room entrance doors from Messrs Mine Safety Appliances.

2.10. LIST OF ABBREVIATIONS

AAAC	All Aluminum Alloy Conductor
AAC	All Aluminum Conductor
AC	Alternating Current
ACO	Automatic Change Over
ACSR	Aluminum Conductor, Steel Reinforced
AIS	Air Insulated Switchgear
AMF	Automatic Mains Failure
ANSI	American National Standards Institute
AUX	Auxiliary
BEP	Basic Engineering Package
BIL	Basic Insulation Level
BMS	Building Management System
CFL	Compact Fluorescent Lamp
CT	Current Transformer
DC	Direct Current
DB	Distribution Board
EIA	Environmental Impact Assessment
EMI	Electromagnetic Interference
GPS	Global Positioning Satellite
HMI	Human Machine Interface
IEC	International Electro-technical Commission
ICASA	Independent Communication Authority of South Africa
IED	Intelligent Electronic Device
IEE	Institute of Engineers
IEEE	Institute of Electrical and Electronic Engineers
IRP	Interface Relay Panel
ISO	International Standards Organisation
JB	Junction Box
LED	Light Emitting Diode
LV	Low Voltage (525 V)
LVT	Low Voltage Terminal
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MD	Maximum Demand
MV	Medium Voltage
MLV	Main Low Voltage
MSC	Mobile Switching Centre
NBR	National Building Regulations
NEC	Neutral Earthing Compensator
NER	Neutral Earthing Resistor
OLTC	On Load Tap Changer
ONAN	Oil Normal Air Normal – Cooling Class for Transformers

PC	Personal Computer
PILC	Paper Insulated Lead Covered
PMC	Protection Metering and Control
REF	Restricted Earth Fault
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SABS	South African Bureau of Standards
SAS	Substation Automation System
SCADA	Supervisory Control and Data Acquisition
SHMI	Substation Human Machine Interface
VT	Voltage Transformer
XLPE	Cross Linked Polyethylene

2.11. LIST OF DEFINITIONS

Bare Conductor	Conductor with no insulating covering.
Basic Insulation Level	The insulation level of the overall electrical network against lightning and/or switching surges.
Clearance	The shortest distance between two conductive parts
Conductor	An electrical material arranged to be connected to a source of electrical energy for the purpose of transporting the energy to a different point in the network.
Contractor	The person, partnership, company or firm appointed for the supply, installation, testing, commissioning and maintenance of the RMU. In the case of the installation being a sub-contract, nominated in terms of the main contract or otherwise, the word "Contractor" also means "Sub-Contractor" in terms of the sub-contract conditions for the specific installation. Where applicable the builder or principal contractor is referred to as "Main Contractor".
Document	The complete set of contract documents, including Conditions of Tender, Conditions of Contract, the Standard Specification for Ring Main Unit, the Standard Specification for Electrical Installations, and the Project Specification, including all drawings and variation orders and Engineer’s instructions issued in terms of the Contract.
Drawings	Drawings forming part of the contract documents and any modification thereof or additions thereto delivered to the Contractor during the execution of the works.
Earth Conductor	A conductor that provides an electrical connection between electrical equipment and an earth electrode.
Earth Electrode	A conductor in direct contact (low impedance) with earth.
Earth Resistivity	The resistance between the opposite faces of a cube of earth having sides of 1m in length.
Earth Rod	A metal rod driven into ground to act as earth electrode.
Ground Clearance	The minimum distance between a conductor and ground level in a span with the conductor at its maximum design temperature.
High Voltage	A voltage level of >33kV and <132kV
Insulator	A device that provides electrical insulation and mechanical fixing to conductors that is subject to potential differences.
Medium Voltage	All equipment of rated voltage from 3,3 kV to 33 kV.
Metal Clad	Metal enclosed switchgear in which components are arranged

	in separate compartments with metal partitions intended to be earthed.
Project Specification	The Project Specification that is drawn up as a supplement to the Standard Specification for Ring Main Unit (this document) to specify items, conditions and requirements for a particular contract not covered by this Specification. The Project Specification has preference over this Specification.
Responsible Person	A person appointed by the Contractor in terms of the requirements of the Occupational Health and Safety Act who shall take all responsibility for the compliance with the Act of any of their staff, labour and sub-contractors and all installations and equipment operated and plant installed by the Contractor.
Rated Voltage	The highest RMS phase to phase voltage for which a specific piece of electrical equipment has been designed for.
Relay	Multifunction protection, metering, control, automation and communication device. Also commonly referred to as an intelligent electronic device (IED).
Servitude	A piece of land for which the right of entry for the purpose of installation, operation and maintenance of a power system has been given to a supply authority by way of law and registered against the title of the property.
Surge Arrestor	A device designed to protect electrical equipment against high transient over-voltages usually caused by lightning or switching surges.
Switchgear	All components directly associated with the main power circuit of the switchboard, including bus bars, circuit breakers, fused contactors, enclosures and associated equipment.
Switchboard	An indoor assembly of switchgear and control gear.
Switchyard	An outdoor assembly of switchgear and other electrical equipment configured for the purpose of distributing energy.

2.12. MAINTENANCE

1 The Sub-contractor shall maintain and service the Plant, in accordance with the following requirements for a period of twelve (12) months calculated from the date of the "Acceptance Certificate" or, in the event of more than one certificate having been issued by the Engineer, from the respective dates so certified.

2 Scan and send the maintenance records every month to the HVAC Engineer.

3 During the 'Maintenance Period' the Sub-contractor shall maintain and service the Plant regularly at monthly intervals and make good any Defects in accordance with the provisions of these Specifications.

4 The Maintenance of the Plant shall be carried out during normal working hours or out of normal hours if necessary and at each service the Sub-contractor shall attend to the following:-

5 Report to an official nominated by the Employer on arriving and again on leaving the Works. Such person shall complete and sign the monthly 'Service Report'.

6 Check the function of each item of the Plant including all automatic controls and safety devices for correct operation and lubrication, adjust, clean and/or replace components and ancillaries as necessary.

7 Clean all washable air filters and check all disposable media type air filters serving the air conditioning plants for pressure drops, fitting additional filter material, if required.

8 Check all refrigeration systems for leaks, refrigerant dryness, and sufficient oil in the compressors, sufficient refrigerant gas or any other defect.
9 Check the electrical switchpanels replacing any burnt contacts or pilot lamp bulbs which have failed.
10 Take and record Wet and Dry Bulb temperatures in each of the conditioned areas and outside. Temperature readings shall be taken with a reliable sling psychrometer and all readings shall be recorded on the 'Service Report'.
11 Attend to any complaints made with respect to the Plant, by the official nominated by the Employers, being the only person authorised to instruct the Sub-contractor or make any complaint, (other than the Engineer.) No other person shall have any right to instruct or make any complaint to the Sub-contractor.
12 While attending to any Defects and the Servicing of the Plant, the Sub-contractor shall not unduly disturb the functions of the occupants in the areas concerned.
13 The one (1) year maintenance period shall commence on the date of the issue of the acceptance certificate. The first service to take place 1 month after date of acceptance certificate. The Sub-contractor shall notify the Engineer and Client in writing 14 days prior to this service so that the Engineer and the Client's representative may be present during the services.
14 It is an explicit condition of this enquiry that all work carried out in pursuance of this tender enquiry will be guaranteed against failure or defect whatsoever for a period of 12 months from the time of acceptance by the Client.
15 Any costs for labour, materials, etc., which the Sub-contractor incurs whilst maintaining the above guarantee for the specified period shall be borne by the Sub-contractor.

2.13. MATERIAL SUBMITTAL GUIDELINES

The following guidelines to be followed in the preparation and processing for review of equipment and material submittals;-

1. Failure of the contractor to comply to these guidelines will result in a non-approval of the submittal, and the consultant will not be responsible for any time delays due to this. Once a supplier is approved or approved as noted in a material submittal, the engineer reserves the right to refuse another supplier for the same material. The engineer spends considerable time in approving of submittals, especially major equipment.
2. All equipment/material submittals to be issued in triplicate, or more if required by the Project Managers/Main Contractor on the Project.

2.13.1.1. Submittal Review Request Cover Sheet

1 Each submittal shall include a Cover Sheet in terms of the Project Managers/Main Contractors requirements.
2 As a minimum the following information shall appear on the Submittal Review Request Cover Sheet.
   a) Project Name
   b) Main Contractor Name
   c) Consultants Name
   d) Submittal number
   e) Submittal revision number
   f) Submittal date
   g) Sub-Contractor Name

h) Local Supplier/Agent Name
i) Manufacturers Name
j) Submitted Product Description
k) Space for Main Contractor's representative name, signature and date.
l) Space for Sub Contractor's representative name, signature and date.
m) Space for Consultants review comments.
n) Space for Consultant's representative name, signature and date of submittal receipt and date of review.
o) Review status to be ticked by Consultant i.e. A Approved B Approved subject to comments C Revise and resubmit D Not Approved
p) Samples to be submitted along with the material submittal. Samples to be clearly tagged.

2.13.1.2. Index

1 A standard index page to be provided incorporating the below listed sections, as well as the applicable number of pages per section. Where sections consist of pre-printed brochures etc., the page numbers can be added by hand in the bottom RH corner of the page, i.e. page 1 of 12, page 2 of 12, etc. The typed Index page to then indicate for that section page numbers 1 to 12. If for a specific submittal some of the sections should not be applicable, then on the Index N/A to be shown under the Page numbers

Example

Number	Description	Page
1	Schedule of equipment/material	1 to 3
2	Specifications	1 to 7
3	Compliance statement	1 to 3
4	Brochures/Technical data sheets/etc	1 to 12
5	Dimensional drawings	1 to 1
	Wiring diagrams (where applicable)	N/A
7	Performance curves (where applicable)	N/A
8	Company profile	1 to 1
9	Client reference list	1 to 1

Add any additional sections considered necessary from section 10 onwards.

2.13.1.3 Section 1 – Schedule of equipment/material

1 Only related/similar equipment/materials from the same Supplier may be grouped together in one submittal. It is however preferred to split submittals as far as possible in order not to delay approval of some equipment/materials because others grouped in the same submittal did not receive approval.
2 Under this section provide schedules of equipment/materials indicating different sizes/model numbers/reference numbers included as part of the submittal.

2.13.1.4 Section 2 – Specifications

1 Under this section include extract photo copies of the applicable specifications

i.e. Consultant's Standard specification

Consultant's Detailed specification

Extracts from Consultant drawings incorporating product specification data.

2 Number specification pages consecutively by hand to be used on the Index page.

2.13.1.5 Section 3 – Compliance statement

1 The compliance statement section pages to be typed to consist of the following:

Spec clause & number	Compliance	Notes
Short description of the specification indicating the gist of each component of the specification clause separately	Under this column only the words ***Yes, No*** or ***Not applicable*** to appear.	Under this column provide reasons for Non-compliance only when compliance is ***No*** or ***Not applicable***

In revised submittals, the contractor must include a compliance statement to the previous file note or comments.

2 No description to appear under the Notes column when Yes under the compliance column. Should extensive description be required under the Notes column, then reference could be made to an attachment at the end of the Compliance statement. Include under the section page numbers

3 In case of items that require the main or subcontractor's compliance, this must be done in a separate compliance statement. Normally the supplier says *Not applicable*, and this is not acceptable.

2.13.1.6. Section 4 – Brochures/Technical Data Sheets, etc

1 Under this section include Manufacturers technical information. The information included under this section shall be Job Specific, and any non-relevant or not applicable parts shall be clearly crossed or blanked out and signed next to it by the Subcontractors representative. It shall be assumed that any data not crossed out forms part of the equipment/materials offered at no extra cost, even if not specifically specified.

2 Under this section list the applicable Standards and Codes of Practice in accordance with which the offered product/materials is manufactured and tested.

2.13.1.7. Section 5 – Dimensional Drawings

1 When reviewing the submitted dimensional drawings of equipment/materials offered it will be assumed that dimensional information included has been checked by the Sub-contractor for physical fit, coordination, required performance as well as maintenance and installation access purposes.

2.13.1.8. Section 6 – Wiring Diagrams (where applicable)

1 When reviewing the product wiring diagrams submitted as part of equipment submittals it will be assumed that this has been checked by the Sub-contractor in terms of the project power supply provisions and has been coordinated as part of the total electrical installation in terms of the specification requirements.

2.13.1.9. Section 7 – Performance Curves (where applicable)

1 Performance curves shall include marked-up operating duty points (system curves) under expected job specific operating conditions. Under this section include all relevant calculations with support information from which the duty points have been determined. Pumps in parallel shall include combination pump curves and system curves at different speed operational conditions. Pump head and fan pressure calculations to include all system component support technical data on which basis the calculations have been based. Acoustic calculations shall include component absorption calculation data from the source to the point of use.

2.13.1.10. Section 8 – Company Profile

1 Under this section include details of both the Manufacturer as well as the Local Supplier. Physical and e-mail addresses, contact persons and telephone numbers, etc.

Specific reference to be made under this section to the following:

2 Manufacturer's Quality Control Rating. Include Applicable Certificates. If components are being sourced out include Quality Control certificates for all Sub suppliers.

3 Manufacturer's Country of Origin. Include for all components, as well as Country of machining, assembly and testing.

4 Include information as to the period from when the Local Supplier represented the specific offered product.

5 Include the proposed supplier's/manufacturer's Warranty Certificate.

2.13.1.11. Section 9 – Client Reference List

1 Under Client reference list include the following information:

2 Completed projects in the last 3 years on which the product was used, Client's representative contact name and telephone number.

3 List Projects under construction for which the product has already been approved/ordered/delivered/installed, with Consultant's and Sub-contractor's representative contact names and telephone numbers.

2.14. SCHEDULE OF APPLICABLE STANDARDS

1 The schedule below lists the relevant standards that are applicable to equipment supplied for various electrical equipment and installations. All equipment and/or parts of equipment must comply with all the relevant standards given below with respect to safety, quality and performance.

2 Standards referred to in this Specification are the latest edition, including all amendments, published three calendar months or longer before the closing date of tenders.

DESCRIPTION	STANDARD
Busbars	SABS 1195
Busbars, trunking systems	SABS 1473-2
Bushings, for transformers	SABS 1037
Bushings, for transformers and reactors	SABS IEC 60137
Bushings, standard transformer bushings	SABS 833
Bushings, transformers, ceramic hollow insulators	SABS 1371
Cabinets, electricity supply meters	SABS 908
Cables, PVC insulated cables for fixed installation, 300/500 V to 1900/3300 V	SABS 150
Cable boxes, transformers and reactors	BS 2562
Cable glands, for flameproof enclosures	SABS 808
Cable glands, mechanical	SABS 1213
Cable ties	NRS 020
Cable trunking and ducting system, General requirements	SABS IEC 61084-1
Cable trunking and ducting systems intended for wall or ceiling mounting	SABS IEC 61084-2-1

DESCRIPTION	STANDARD
Cable, bitumen-based filling compounds	BS 1858
Cable, boxes, sealing and dividing boxes	BS 542
Cable, cord sets and cord extension sets	SABS 1661
Cable, flexible cables and cords	SABS 1574
Cable, heat resisting wiring	SABS 529
Cable, materials	SABS 1411
Cable, pilot cables	NRS 011
Cable termination, enclosures for air termination 7,2kV to 36kV	NRS 008
Cable, pilot cables	NRS 011
Cable, PVC insulated cables for fixed installations, 300/500 V to 1900/3300V	SABS 1507
Circuit breakers, LV	SABS IEC 60947-2
Circuit breakers, earth leakage protection units	VC 8035
Circuit breakers, earth leakage protection, fixed units	SABS 767-1
Circuit breakers, high voltage a.c.	SABS IEC 60056
Circuit breakers, high voltage a.c.	IEC 62271-100
Circuit breakers, moulded case	SABS 156
Circuit breakers, moulded case	VC 8036
Circuit breakers, residual current operated circuit breakers without integral over-current protection	SABS IEC 61008-1
Classification of degrees of protection provided by enclosures	IEC 60529
Common specifications for high-voltage switchgear and control gear standards	IEC 60694
Conduit, fittings for conduit, steel, screwed and plain-end	SABS 1065-2
Conduit, flexible materials	SABS IEC 60614-2-5
Conduit, Steel, Screwed and Plain-end	SABS 1065-1
Conduit, unplasticised polyvinyl chloride (uPVC)	SABS 950
Cubicles, power distribution, outdoors, cable networks	SABS IEC 60439-5

Distribution boards, safety	SABS 1765
Distribution boards, small units (ready boards), single phase	SABS 1619

DESCRIPTION	**STANDARD**
Earthing, earth rods and couplers	SABS 1063
Earthing, portable earthing gear for bus bars or overhead lines	SABS IEC 61230
Electrical Relays	IEC 60255
Enclosures, electrical equipment, classified by IP code	SABS 1222
Flame proof, electrical enclosures, explosive gas atmospheres, construction and verification test	SABS IEC 60079-1
Flame proof, electrical enclosures, for use in the presence of combustible dust	SABS IEC 61241-1-1
Flanges	BS 4504
Fuses, high voltage, current limiting and expulsion fuses	SABS 1779
Fuses, low voltage	SABS 172
Fuses, low voltage	SABS IEC 60269-1
Fuses, low voltage, for semiconductor devices	SABS IEC 60269-4
Fuses, low voltage, household applications	SABS IEC 60269-3
Fuses, low voltage, industrial	SABS IEC 60269-2
Fuse-switch combinations, high voltage a.c.	SABS IEC 60420
Galvanised coatings, hot dip, for fabricated iron and steel articles	SABS ISO 1461
Galvanised coatings, hot dip, for steel tubes, internal and/or external, applied in automatic plants	SABS EN 10240
Lubrication nipples and adaptors	BS 1486
Lugs and ferrules	NRS 028
Meters, direct acting, indicating, analogue, accessories	BS 89-8
Meters, direct acting, indicating, analogue, ammeters and voltmeters	BS 89-2
Meters, direct acting, indicating, analogue, frequency meters	BS 89-4
Meters, direct acting, indicating, analogue, multi-function instruments	BS 89-7
Meters, direct acting, indicating, analogue, ohmmeters, and conductance meters	BS 89-6
Meters, direct acting, indicating, analogue, phase meters, power factor meters and synchroscopes	BS 89-5
Meters, direct acting, indicating, analogue, watt-meters and var-meters	BS 89-3
Meters, electromechanical watt-hour meters	SABS 1607
Meters, maximum demand indicators, class 1.0	SABS IEC 60211

DESCRIPTION	**STANDARD**
Meters, static watt-hour meters a.c., for active energy, classes 1 and 2	SABS IEC 61036
Outlet boxes, enclosures for accessories, household and similar electrical installations, general requirements	SABS IEC 60670
Outlet boxes, wall mounted	SABS 1085
Paint, resistance to salt fog, test method	SABS SM 155
Painting, identification colour marking, hazards and equipment	SABS 0140-2
Painting, national colour standards	SABS 1091
Painting, preparation of steel surfaces for coating	SABS 064
Quality management	SABS 0157
Socket outlets, plugs and couplers, industrial	SABS 1239
Socket outlets, plugs and couplers, industrial, general	SABS IEC 60309-1

requirements	
Socket outlets, plugs and couplers, interchange ability of components (pin and contact tube)	SABS IEC 60309-2
Socket outlets, plugs, adaptors	VC 8008
Socket outlets, plugs, fixed installations, 16A 250V	SABS 164-2
Socket outlets, plugs, fixed installations, conventional systems	SABS 164-1
Socket outlets, plugs, fixed installations, SELV, 16A 6V, 12V, 24V, 48V a.c. or d.c.	SABS IEC 60906-3
Socket outlets, plugs, fixed installations, socket outlets with interlock	SABS IEC 60884-2-6
Socket outlets, plugs, fixed installations, switched socket outlets without interlock	SABS IEC 60884-2-3
Socket outlets, plugs, SELV	SABS IEC 60884-2-4
Surge arrestors, low voltage, performance and tests	SABS IEC 61643-1
Surge arrestors, metal oxide surge arrestors without gaps for a.c.	SABS IEC 60099-4
Surge arrestors, non-linear resistor type gapped surge arrestors for a.c.	SABS IEC 60099-1
Steel sheet, continuous hot-dip zinc carbon sheet steel of commercial, lock forming and drawing grades	SABS ISO 3575
Steel sheet, continuous hot-dip zinc-coated steel sheet of structural quality	SABS ISO 4998
Switches, appliances, requirements and safety	SABS IEC 61058-1
Switches, earthing switches and disconnectors, a.c.	SABS IEC 60129
Switches, fixed installations, electronic switches	SABS IEC 60669-2-1
Switches, fixed installations, general requirements	SABS IEC 60669-1
Switches, fixed installations, manually operated	VC 8003
Switches, fixed installations, manually operated, safety	SABS 1663

DESCRIPTION	**STANDARD**
Switches, fixed installations, remote control switches	SABS IEC 60669-2-2
Switches, fixed installations, time delay switches	SABS IEC 60669-2-3
Switches, high voltage, above 1kV and less than 52kV	SABS IEC 60265-1
Switches, load-break switch-disconnectors, pole mounted, above 1kV up to 36kV a.c.	NRS 046
Switches, low voltage, air break switches, air break disconnectors, air break switch-disconnectors, fuse-combination units	SABS 152
Switchgear, low voltage, automatic transfer switching equipment	SABS IEC 60947-6-1
Switchgear, low voltage, control and protective switching devices	SABS IEC 60947-6-2
Switches, low voltage, proximity switches	SABS IEC 60947-5-2
Switches, low voltage, switches, disconnectors, switch-disconnectors, fuse-combination units	SABS IEC 60947-3
Switchgear, low voltage, electromechanical control circuit devices and switching elements	SABS IEC 60947-5-1
Switchgear, low voltage, emergency stop device with mechanical latching function	SABS IEC 60947-5-5
Switchgear, low voltage, automatic transfer switching equipment	SABS IEC 60947-6-1

Switchgear, low voltage, control and protective switching devices	SABS IEC 60947-6-2
Switchgear, low voltage, emergency stop device with mechanical latching function	SABS IEC 60947-5-5
Switchgear, low voltage, semiconductor motor controllers and starters a.c.	SABS IEC 60947-4-2
Switchgear, low voltage, semiconductor controllers and contactors a.c. for non-motor loads	SABS IEC 60947-4-3
Switchgear, metal-clad, above 1kV up to 36kV a.c.	SABS 1885
Switchgear, metal-clad, above 1kV up to 24kV, standardized panels, preferred requirements for indoor application	NRS 003-2
Switchgear, metal-enclosed, above 1kV up to 52kV	SABS IEC 60298
Terminals, compression and mechanical connectors for copper or aluminum conductors, tests and requirements	SABS IEC 61238-1
Terminals, protective terminal blocks for copper conductors	SABS IEC 60947-7-2
Terminals, terminal blocks for copper conductors	SABS IEC 60947
Terminals, wiring, terminal blocks	SABS 1433-1
Terminals, wiring, push-on connectors	SABS 1433-2
Wiring of premises, low voltage installations	SABS 0142-1
Fresh air supply	SANS 10400 Part O SANS 10108 Ashrae 62.1
Air filtration	EN779 EN1882 Eurovent 4/9
Acoustic	SANS 10103
Water Piping	SABS 719 SABS

DESCRIPTION	**STANDARD**
Refrigeration Piping	SANS 10147
Welding	ASTM A234 WPB ASTM A106 GRADE B
HVAC Equipment	Chiller - PED 2014/68/EU
Energy room indoor conditions	SABC Standard
Battery room ventilation	SANS 10108
Water treatment for close chiller water systems	BSRIA BG50 which replaced **AG 2/93.**

2.15 SPARE PARTS

1 The Sub-contractor shall deliver the following spare parts to the Employers for safe-keeping by the latter in order that repairs to the Plant can be executed with minimal delay, such parts being provided packaged in complete sets each duly labelled with their function.

- ONE set of match V-belts for each different belt drive;
- ONE set of bearings for each different fan size;

- ONE pilot lamp bulb for each pilot light specified on the drawings to match those installed in the Electrical Switchpanel and a bulb extractor if required;
- ONE set of filters for each Air Conditioning and Ventilation system is to be handed to the clients representative on final completion of the Works;
- TWELVE months supply of chemicals for the Chemical Dosing Plant, where applicable.
- ONE complete set of "O"-rings and filter for the electronic water treatment unit.

The necessary chemicals for bacterial, legionella and algae control shall be included for the purpose of water treatment required to supplement the non-chemical electronic water treatment unit.

2.16. STANDARDS, CODES, REGULATION AND MATERIAL

1 The installation shall be carried out in accordance with the following standards and relevant local regulations, bylaws, and Codes of Practise. The specific standards referred to, shall be deemed to refer to the current edition of the Standard including any amended standard requirements, which may become current before the date at which the Works are to be carried out.

- Local Authority Codes and Statutory Requirements
- South African Standards and Codes of Practice
- The requirements for Electrical Installation – IEE Wiring Regulations – 16th Edition (BS 7671 : 1992), issued by the Institute of Engineers
- Operational Health and Safety at Work
- The Workplace (Health, Safety and Welfare) Regulations -The Health and Safety (Display Screen Equipment) Regulations -The Management of Health and Safety at Work Regulations -The Provision and Use of Work Equipment Regulations - The Personal Protective Equipment at Work Regulations -The Manual Handling Operations Regulations -The Construction (Design and Management) Regulations
- Electricity at Work Regulations
- The Building Regulations
- Containment of Substances Hazardous to Health Regulations (COSHH)
- The Environmental Health and Safety Officer
- Factories, Shops and Offices Act 1948
- Manufacturers Recommendations for Installation, Testing and Maintenance
- Requirements of Employers Insurers

2 Material and work shall comply with the above specifications and Codes of Practice where applicable. Where no such standards exist the equipment shall include for the known factors and requirements.

3 Material and components shall be handled on site in such a manner as to avoid any damage or contamination. Manufacturer’s handling and storage recommendations shall be adhered to.

4 All items shall be stored clear of the ground, under cover, and protected in such manner as to preserve their quality and condition to the standards required by the specification.

5 The Controls Subcontractor shall confirm that the manufacturers and type of materials specified are suitable and available and shall then place on order all material required to carry out the installation and in order to meet the agreed programme.

2.17. WORKMANSHIP

2.17.1.1. Tools, Equipment and Material Storage

1 The Contractor shall provide all the correct tools, equipment, appliances, materials and all sundries necessary for the proper execution of the Contract, whether mentioned in the Specification or not.

2 The Contractor must make their own arrangements regarding transport and off-loading of labour and materials and shall provide their own plant.

3 The Contractor will be responsible for the safe storage of all equipment, plant and materials, and will be held responsible for loss by theft or damage in any way, whether installed on the Contract or not.

4 The Contractor shall ensure that stored equipment and materials do not overload the structure or floor construction.

5 The storage of combustible materials on site shall be kept to a minimum. The Contractor shall ensure that such combustible materials are safely stored. Suitable fire fighting equipment shall be provided by the Contractor, who shall further ensure that staff capable of using the equipment is at hand.

2.17.1.2. Transport

1 The electrical equipment that shall be installed is to be transported to site for off-loading and installation purposes as specified in the Project Specification.

2 It is the responsibility of the Contractor to fully inform themselves of the requirements and limitations laid down by the South African Transport Services regarding the transport of the equipment, and to comply with these requirements where applicable.

3 Where special arrangements are required for transporting of the equipment, the necessary application shall be made and drawings submitted to the Provincial Road Authorities and South African Transport Services for approval. Copies of these documents shall be submitted to the Engineer for their records.

4 Where the equipment is to be transported by road only, the requirements of the Provincial Road Authority shall be complied with.

2.17.1.3. Erection

1 Unless otherwise specified the Contractor’s tender price shall include for the off-loading, fitting, handling, positioning and installation of the equipment.

2 It is the responsibility of the Contractor to remove and clear all erection equipment materials, packaging and rubble from site after completion of the erection process.

3 If electricity is not available on site, the Contractor shall be required to make their own arrangements for the provision of portable generating equipment required for

erection and installation. The cost for the provision of the generating equipment shall be included in the total Contract sum.

2.17.1.4. Co-operation with Other Trades

1 The Contractor shall closely collaborate with the Main Contractor and their Subcontractors for the entire duration of the Contract. Failure of either party to co-operate renders the non-cooperating party liable for all costs deemed necessary to rectify any resulting unsatisfactory work.

2 The Contractor shall ascertain the extent of the work of other trades on site which may affect, or be affected by the Contractor's installation.

3 The Contractor shall give all necessary assistance reasonably required to other trades to ensure that the work of such trades can be installed satisfactorily and without delay.

4 The Contractor shall liaise with other trades working in close proximity to the work, covered by this Specification, and shall assist in working out equipment and material positions to ensure that all trades can complete their work satisfactorily.

5 It is the responsibility of the Contractor to check the builder's work as it is completed to ensure that the work has been correctly carried out in accordance with the drawings. [Refer to Builder's Work Drawings].

6 The Contractor shall point out any problem areas as soon as possible to the Principal Contractor (Builder) so that these problems can be rectified.

7 No claims shall be considered for delays or other additional costs which arise out of the Contractor's failure to check the builder's work in good time.

8 All areas where the installation pierces waterproofing shall be carefully finished and sealed by the Contractor and the Principal Contractor (Builder) to the approval of the Engineer. All necessary sleeves, caulking and flashing as required to make the installation waterproof shall be provided as part of the Contract.

2.17.1.5. Workmanship

1 The Contract shall be executed with the best workmanship in a workmanlike manner and to the satisfaction of the Engineer. Should any material or workmanship not be to the satisfaction of the Engineer, it shall be rectified at the cost of the Contractor and all rejected material shall be removed from site.

2 The Contractor shall employ only competent artisans to carry out the Installation on site. Trainees may be used under strict supervision and only in the performance of tasks which do not require fully qualified artisans for their completion.

3 The Contractor shall be responsible for the correct and complete erection of the installation. Inspections by the Engineer will not release the Contractor from this responsibility. All installations shall be complete and functional in every respect as indicated in the Contract scope of works and the Project Specification pertaining to the specific installation.

4 On completion of the Contract, any damage which may have been done to finished plaster work, floors, ceilings, wood and paint work, etc., during the progress of the Gas Generator installation, shall be repaired and made good to original finishes by

the Contractor, to the satisfaction of the Engineer. Should the Contractor not carry out this remedial work, then it shall be done by others at the cost of the Contractor.

5 The Contractor shall supply and install all notices and warning signs that are required by the appropriate laws or regulations and/or by this Specification.

7 Under no circumstances are workmen to be allowed to sleep or deposit any kit on the premises either during or after building operations.

2.17.1.6. Quality of Material and Equipment

1 The Contractor shall institute and maintain a suitable quality management system, complying with SABS 0157 as amended, to ensure that only materials and equipment meeting the requirements of this Specification are used during the execution of the work. The quality management system must comply with ISO 9000 part 1 and ISO 9001, 9002, 9003 and ISO 9004 parts 1 and 3 as amended.

2 Only material of the highest quality, equal to or exceeding the specified properties and qualities contained in the Specification shall be used and shall be subject to the approval of the Engineer.

3 Unless otherwise specified or approved, all material and equipment shall conform in respect of quality, manufacture, tests and performance with the requirements of the South African Bureau of Standard (SABS), or where no such standards exist, conform to the appropriate IEC specification or the specification of the British Standards (BS) Institution, and shall bear the relevant certification mark. The Contractor shall provide the relevant certificate of compliance when called upon to do so. Material and equipment that does not comply with SABS or BS standards shall be approved by and installed to the satisfaction of the Engineer.

4 Only new, un-used materials and equipment of the best quality available shall be installed. The arrangement of the installed equipment shall be in accordance with the best current practice. Special care shall be taken to ensure neatness in all parts of the Installation.

5 All materials and equipment shall be suitable for the purpose for which they are employed and for the conditions on site. These conditions shall include weather conditions as well as prevailing conditions during storage, installation and subsequent use. Should the materials or components not be suitable for use under temporary site conditions, the Contractor shall provide at their own cost suitable protection until these unfavourable site conditions cease to exist.

6 Material manufactured in South Africa shall as far as possible be used. Imported materials shall comply with the requirements of the appropriate SABS, IEC, and BS or internationally accepted published comparable standard specification, although these materials need not necessarily bear the SABS mark.

7 The Contractor shall submit samples of any materials or equipment to the Engineer for their approval before installation. The ’client’ will keep the samples for comparison with equipment and materials installed and will only release it on satisfactory completion of the Contract.

8 The electrical installation shall be guaranteed against faulty material, faulty design and poor workmanship, fair wear and tear excepted.

9 If during this period the gas generator installation is not in working order, or not working satisfactorily owing to the faulty material, design or workmanship, the Contractor will be notified and immediate steps shall be taken by them to rectify the defects and/or replace the affected parts on site, at their own expense.

10 The availability of all components shall be guaranteed for a minimum period of 10 years.

2.17.1.7. Painting & Cleaning

1 No untreated metal surfaces shall be permitted on the project. Items, which are not galvanised or similarly protected against corrosion, shall be painted, as later detailed herein. No equipment, hangers, brackets, etc., shall be permitted to be delivered on site in unprotected form; they shall be factory-coated with an approved zinc-rich primer coat before dispatch from their place of manufacture.

2 Painting shall comprise the following consecutive processes. First thoroughly clean, descale and degrease all surfaces, in accordance with acknowledged good practice, follow with a good coating of approved zinc-rich primer and finish with two coats of quality high-gloss enamel of an acceptable make. Final finish shall be to the full approval of the Engineer.

3 With the exception of ducting and piping, items with a galvanised finish, such as cable trays, need not be painted but shall be properly cleaned with a suitable proprietary galvanised iron cleaning fluid.

4 Particular care shall be taken that appropriate primers be used as a basis for painting and that paint be of high quality manufacture, all to provide a completely satisfactory finish to the approval of the Engineer. It shall be noted that galvanised surfaces are to be treated to ensure proper bonding of paint.

5 Whereas it would not be necessary to paint any ductwork, conduits or pipework installed in roof voids, shafts, masonry ducts, etc., or where not normally visible, it is a requirement that such equipment be properly cleaned, treated with two coats of rustproofing paint if not galvanised or not metal subject otherwise to rust.

6 All equipment on the project shall be colour-coded in accordance with standards recognised in the Republic of South Africa and, where possible, to comply with relevant South African Bureau of Standard Colour Codes. (S.A.B.S. 1091-1975).

7 General colour coding for the various items of equipment shall otherwise be as follows. The numbers given in the schedule refer to the colour code numbers of S.A.B.S., 1091-1975.

8 Any alternative colours shall be approved by the Engineer.

9 All equipment shall be painted in accordance with colour code given and where factory painted items such as the Air Conditioning Units, Cooling Towers and Pumps are not painted a specified colour they shall be repainted by the Sub-contractor.

10 Factory painted equipment which is required to be repainted to comply with the specified colour code shall be rubbed down prior to being given two coats of gloss enamel paint, or as required in accordance with the paint manufacturer's recommendations and depending upon the type of paint applied at the factory.

3. ELECTRICAL & ELECTRONIC SPECIFICATIONS

3.1. AUTOMATED CONTROLS & BUILDING MANAGENENT SYSTEM

3.1.1. GENERAL

3.1.1.1. SCOPE OF WORK

1 The Subcontract, as detailed in these Specification Document(s) and the accompanying Drawing(s), comprises of the manufacture, supply, transport and delivery, hoisting, installation, testing, setting in operation, leaving in complete working order, guarantee-component replacement of the entire Building Management System and/or the automated control system, except so far as the subcontract otherwise provides, the provision of all labour, materials, contractor's equipment and everything, whether of a temporary or permanent nature required in and for such manufacture, supply, offloading, hoisting, installation, testing, setting in operation, leaving in complete working order, guarantee so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract.

2 The following related work to the Building Management System sub-contract will be provided by others. The BMS contractor shall be responsible for the detailing, checking and ensuring that the work as listed in the schedules and shown in principle on the drawings is provided as per his detailed builder's work and related services drawings.

3 Instructions for the BMS contractor's exact requirements shall be transmitted to the Principal contractor and other sub-contractors timeously in the form of builder's and associated services drawings in accordance with an agreed programme. Should these instructions be issued after the completion of relevant areas, then this work will be carried-out at the expense of the BMS contractor.

4 The onus is on the BMS contractor to check the schedules (ECD and other) and ensure that all the items required for the successful completion of the works have been included. Any items shown on the drawings that are required by the specification but not clearly defined or described in the Bill must be added at the end of each section.

5 The successful tenderer (contractor) will be required to produce “double line” shop drawings as well as co-ordinated services drawings and sections which are co-ordinated with the structure for approval by the Engineer. The successful tenderer (contractor) shall be responsible for producing builders work drawings relating to the BMS installation.

6 If a shop drawing has not been approved by the engineer, it is the contractor’s full responsibility to resubmit the shop drawing, signed off by the responsible contractor, ensuring that all the engineers’ comments have been implemented. If the contractor fails to comply with this, any time delays resulting in resubmitting of shop drawings will be a delay caused by the contractor, and not the engineer. If the engineer find that more than 5 comments on any particular revised shop drawing is repeated, the shop drawing will be returned at once with status as not approved. All shop drawings and material submittals to be submitted formally and engineer reserves the right not to accept advanced copies.

7 During tender stage, should there be a discrepancy between any of the equipment schedules or any other material on drawings, tender specifications, BOQ'S or any addendums, the contractor to allow in his cost for the most stringent and worst case selections and equipment.

8 The contractor must confirm equipment procurement periods after receiving tender documents. Material submittals must be submitted in line with the main contractors programme, taking into account that there might be various revisions (mainly due to incomplete submittals).

9 The system design and tender drawings have been based on certain equipment makes and model numbers as stated in this specification and shown on the drawings. It is required that tenderers base their main offers on the equipment on which the tender design has been carried out.

10 Any later claims for extras based on additional costs, for changing from manufacturer A to manufacturer B, might be rejected. In addition it shall be the tenderers responsibility to ensure that equipment offered, if other than that shown on the tender drawings, can be accommodated within the available plant areas and plantrooms.

11 Tenderers are to allow for carrying out 13 service and maintenance visits to the plant, during the first year of operation, and for a full 12 month guarantee period, all as set out in the BMS specifications. A detail report is required with photos, after each visit. This allowance is to include for the specialist services if required.

12 The contractor is to allow in their tender costs *for the most stringent specification*, should there be any conflict in any of the BMS tender documents (e.g. HVAC General Technical specification, HVAC Project Technical specification. drawings, BOQ, control schematics, points lists, BOQ, Equipment schedules etc.

13 The engineer reserves the right to change the supplier/product of any equipment from project to project (as per manufacturers/suppliers names in the specification) even if the engineer has approved a supplier or product on a previous project.

3.1.1.2. TENDER DRAWINGS

1 The Drawings accompanying this Specification as shall be deemed to indicate the general layout and requirements only and are not Shop Drawings.

2 The Engineer shall provide the contractor, free of charge and on written request, with one sets of Specification Documents and one CD, to include all Tender Drawings

4 The tenderer to check and ensure that all drawings as listed on the drawing register have been received and priced, including equipment schedules in specifications, annexures, addendums and drawings.

3.1.1.3. ARCHITECTURAL AND STRUCTURAL DRAWINGS

1 The sub-contractor shall ensure that he is in possession of all information required for the installation of the Works and shall, if necessary, obtain copies of all relevant Drawings from the Architect and Structural Engineer so named in the documentation.

3.1.1.4. WORK INCLUDED

1 Provide a new building automation system to control and monitor the building's mechanical and electrical systems. The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type. LONWORKS / BACNET AND MODBUS components not supplied by the primary manufacturer shall be integrated to share common software for network communications, time scheduling, alarm handling, and history logging.

2 Coordinate interface requirements for integration into BMS of the following building-level equipment and systems:

- HVAC System
- Electrical Services Monitoring
- Wet Services Monitoring
- Utility Monitoring/Metering

3 Provide new controllers of the latest revisions with input and output points as specified herein.

4 Provide control valves, control dampers (gravity, fire and smoke control dampers by others or unless otherwise specified), flow switches, thermal wells for pressure and temperature control, and air flow stations as necessary.

5 Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry (as required) and electrical installation, programming, start-up, test and validation acceptance documentation, as-built, maintenance manuals and system warranties.

6 All labour, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfil the functional intent of this specification shall be provided at no additional cost to the client.

7 The work covered by this specification and related sections consists of providing shop drawings, equipment, labour, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BMS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

- The preparation of shop drawings and provision of all related services
- The preparation of submittals and provision of all related services.
- Operator workstations located as listed in the specifications.
- Furnish and install all controllers to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.
- Furnish and load all software required to implement a complete and operational BMS.
- Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.
- Perform acceptance tests and commissioning as indicated.
- Provide full documentation for all application software and equipment.
- Miscellaneous work as indicated in these specifications.

3.1.1.5. WORK BY OTHERS

Principal Contractor

1 The following items are in the scope of the builder contractor, not the BMS contractor;

- All plant areas to house *BMS EQUIPMENT* including equipment concrete plinths, plus all builders work requirements to accommodate the above mentioned equipment on the roof.
- All openings through walls and structural slabs including making 'good' around BMS services, and Fire- and smoke proofing around BMS services to fire engineers specification.
- Openings in suspended ceiling for equipment.
- Ceiling and ceiling construction to support equipment.
- Waterproofing
- Raised access floors including cut outs where necessary for equipment.
- Masonry up stand shafts to house wire-ways.
- All final services coordination with other services, structure, and ceilings with full assistance from the BMS contractor

Mechanical Contractor

2 The following items are in the scope of the mechanical contractor, not the BMS contractor;-

- Setting in place of control valves and dampers, flow meters, water pressure and differential sockets and valves, flow switch sockets, thermal wells, fire and smoke control dampers, air flow stations, and current transformers shall be by others. (Unless specifically instructed by the engineer)
- The installation of motor starters that are not factory installed, thermal overload switches, and power wiring to motors, starters, thermal overload switches, and contactors. This Section includes the furnishing and installation of controls and wiring for automatic controls, electric damper and valve operators, terminal control units, interlocks, starting circuits, and wiring to power consuming control devices.
- Power recirculation to VAV/CAV diffusers for both control and electrical reheat functionality.
- Provide the required AHU MCP's (Motor Control Panels) complete with following;

(Note: The above does not apply to Enclosure/Panels required by the BMS for I/O and/or integration monitoring or connectivity)

- Required electrical switch gear for the equipment c/w overloads and safeties
- Electrical Isolators and circuit breakers
- Indication lamps and buzzers.
- Selector switches and push buttons.
- Analogue Voltage and Current Meters
- Provide a Controls section, separated from the main electrical MCP section.
- Install and wire the "Free Issue" control PLC into the MCP Controls section c/w relays, terminals, panel wiring and power. Provide Interlock/cross wiring between the MCP electrical equipment .e. Contactors, Selector switches, indication lamps etc.

and the corresponding PLC inputs/outputs to provide a functional MCP complete with automated controls.

Plumbing Sub-Contract

3 The following items are in the scope of the wet services contractor, not the BMS contractor;-

- Setting in place of valves, flow meters, water pressure and differential sockets and valves, flow switches and thermal wells shall be by others. (Unless specifically instructed by the engineer)

Electrical Sub-Contract

4 The following items are in the scope of the Electrical contractor, not the HVAC contractor;-

- 230 V, 1 Phase, 3-wire neutral and earth terminating on the live side of the main isolator of the BMS panels in each air conditioning and ventilation plant, for normal and emergency power as specified. The electrical contractor would provide power directly to each control panel (MCP or DB), as indicated on the BMS drawings. The electrical contractor would make off and crimp the connections of the power cable, and the BMS contractor to do the final connection to isolator on the control panel with supervision from the electrical contractor. Electrical contractor to provide the COC up to the panel including final connection
- Fire signal to be provided to all BMS panels as required for monitoring.
- Normal/Emergency electrical supplies change over to all boards. Normal and emergency power supplies fed to BMS switchboards via a single incoming cable - change over contactors in electrical distribution boards.
- Emergency power indicating signal wired to all BMS switchboards, as indicated on the relevant drawings.
- Load shedding signals wired to all BMS switchboards.
- All final terminations in BMS panels by electrical contractor.
- All BMS panels to be "top or bottom entry" type.
- Power distribution from BMS to all BMS related equipment and field devices by BMS contractor.
- Fault Levels 10 kA

3.1.1.6. APPROVED INSTALLERS

1 Provide a building automation system supplied by a company regularly engaged in the installation and distribution of building automation systems. The BMS installer shall meet the following qualifications as a minimum:-

- The installer of the hardware and software components must be primarily engaged in the manufacture of building automation systems as specified herein, and must have been so for a minimum of five (5) years.
- Must have relevant training or certification in the use of the product by the product manufacturer.
- BMS Installer company portfolio must be submitted to the engineer for approval.

2 Approved Equipment:

- SIEMENS (DESIGO, CLIMATICS, SYNCO)
- DISTECH CONTROLS
- TRIDIUM
- SEDONA
- HONEYWELL
    JOHNSON CONTROLS
    SCHNEIDER
    DDC
    TREND

3 Unsolicited bids from Manufacturers or Contractors not listed herein will not be considered.

4 Alternate manufactures must be submitted to the engineer for approval, prior to tender submission.

Note: Where the automated controls shall be a sub-contractor to the HVAC mechanical contract BMS Installer company portfolio must be submitted to the engineer for approval. Failure of such shall result non-approval of BMS installer.

3.1.1.7. QUALITY ASSURANCE

1 Control products such as direct digital controllers, control valves, actuators, sensors and transmitters shall be provided from a reputable manufacturer, and include a 12month guarantee of equipment, peripherals and workmanship from date of practical completion.

2 The installer/supplier of the Building Automation System digital controllers and building management system shall be a proven installer of the product and offer post support and servicing, the contractor shall have in place a support facility located within 100km of the project site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

3 The contractor shall be an Authorized System Integrator in good standing with the Manufacturer Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

4 Upon request, installer shall present records of successful completion of factory training courses including course outlines.

5 Upon request the installer shall provide a letter from the manufacturer that they are a Factory Authorized System Integrator in good standing.

6 Provide satisfactory operation without damage at 15% above and below rated voltage and at 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

7 All controllers provided as part of this system and used for indoor applications shall operate under ambient environmental conditions of 0^0C to 50^0C dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

8 All controllers provided as part of this system and used for outdoor applications shall operate under ambient environmental conditions of 0^0C to 50^0C dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

Commissioning

9 Comprehensive commissioning and quality monitoring are contractually required to be performed by HVAC and BMS Contractors and for the building HVAC control services.

10 The HVAC and Controls installation must be inspected, tested and commissioned in accordance with the following guidelines. The following documents must be submitted at hand-over;

11 Commissioning Checklists

- Records of all actual values, settings, set points and offsets.
- Records of safety interlocks, cut-outs and notifications.
- Records of system level and global checks
- Records of final changes/fine tuning updates.

3.1.1.8. GENERAL WORKMANSHIP

1 Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

2 Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

3 Install equipment in readily accessible locations for maintenance and future access.

4 Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

5 Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

6 Continually monitor field installation for code compliance and workmanship quality.

7 Contractor shall arrange for work inspection engineer / inspector having jurisdiction over the work.

3.1.1.9. SYSTEM PERFORMANCE

1 The Building Automation System shall conform to the following minimum performance standards:

- A Graphic screen shall be capable of displaying a minimum of 20 dynamic points with current data being available within 5 seconds.
- Binary objects shall react to a command within 5 seconds.
- Analog object shall react to a command within 5 seconds.
- Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 seconds.
- Custom or standard applications shall be capable of a Program Execution Frequency as often as once every 5 seconds. Controllers shall be able to completely execute direct digital control PID control loops at a frequency of once per second or faster.
- Each workstation on the network shall be able to receive an alarm within 5 seconds of other workstations.

- System shall be capable to report values with minimum end-to-end accuracy listed in Table 1.9.1 System Accuracy.
- Control loops shall maintain stability and accuracy as measured by the variable at set point within tolerances listed in Table 1.9.2 Control Stability and Accuracy.

Table 1.9.1

Reporting Accuracy

Measured Variable	**Reported Accuracy**
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15ºC (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±4% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 15% - 100% of airflow scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 1.9.2

Control Stability and Accuracy

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±50 Pa (±0.2 in. w.g.)	0-1.5 kPa (0-6 in. w.g.)
	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in.

		w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	MPa (1-150 psi)
	±250 Pa (±1.0 in. w.g.)	0-12.5 kPa (0-50 in. w.g.) differential

3.1.1.10. CO-ORDINATION

1 All work shall be performed at times acceptable to the Engineer/Construction Manager. **Provide work schedule at the start of the job for the approval of the Engineer/Construction Manager**. Schedule shall show when all staff and sub-contractors shall be on-site.

2 Organize all sub-contractors and ensure that they maintain the schedule.

3 Full cooperation/pro-activeness shall be shown with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.

4 Notify Engineer/Construction Manager of any changes to the schedule. Send any schedule changes and weekly progress reports via e-mail to Engineer/Construction Manager.

5 Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference.

6 When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

3.1.1.11. SYSTEM DESIGN AND RESPONSIBILITY

1 The drawings do not show conduit size or wire type to link the various elements of the system. The BMS contractor is responsible for designing these links in view of the present and future capabilities.

2 The Contractor is responsible for supplying sufficient Controllers of all types to meet the intent of the specification. The quantity and point content of the Controllers must be approved by the Engineer prior to point installation.

3.1.1.12. ELECTRICAL WORK, WIRING AND SAFETY

1 Electrical work shall be in accordance SANS and the local Electrical Code. Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel. All wiring shall conform to the most stringent requirements of the local electrical authority.

2 All wiring associated with and required by the BMS shall be the responsibility of this contractor. The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system. If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.

3.1.1.13. NAMEPLATES

1 Nameplates shall be provided for all control items listed or shown in the submittal and approved control diagrams. Each inscription shall identify its function, such as "AHU Controller", "Supply Temperature Sensor" in English and when applicable, its position. Size of nameplates shall be 1 cm by 3 cm minimum. Lettering shall be minimum ½ cm high normal black lettering. Submit duplicate samples of identification tags and lists of wording proposed for approval.

3.1.1.14. PRELIMINARY DESIGN REVIEW

1 The BMS contractor shall submit a preliminary design document for review. This document shall contain the following information:

- Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.
- Provide product data sheets and a technical description of all direct digital controller hardware required to meet specifications listed herein.
- Provide product brochures and a technical description of the Server, Operator Workstation(s), Direct Digital Controller(s) and software required to meet this specification. Provide a description of software programs included.
- Open Protocols - For all direct digital controller hardware Protocol Implementation Conformance Statement PICS or proof of conformance to BACnet Certification and interoperability guidelines including the provision of all controllers must be presented upon request. Provide complete description and documentation of any proprietary services and/or objects where used in the system.
- Provide a description and samples of Operator Workstation graphics and reports.
- Provide an overview of the BMS contractor’s local/branch organization, local staff, recent related project experience with references, and local service capabilities.
- Provide information on the BMS contractor’s project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.
- Project schedule/program of work indicating:
- Intended sequence of work items
- Start date of each work item
- Duration of each work item
- Planned delivery dates for ordered material and equipment and expected lead times
- Milestones indicating possible restraints on work by other trades or situations

3.1.1.15. SUBMITTALS

1 Within 1 week of award of contract and before start of construction, submit x1 hard copy and 1 soft copy of system design and architecture, shop and control drawings.

2 Drawings to be in AutoCAD or VISIO and Sequence of Operations and Points List (Input/output Summary) shall be in Word and Excel format (latest versions) structured using menu format for easy loading and retrieval on the OWS.

3 Provide in completely coordinated and indexed package to assure full compliance with the contract requirements. Piecemeal submittal of data is not acceptable and such submittals will be returned without review. Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work. Arrange the submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended. Submittals for each manufactured item shall be manufacturer's descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalogue cuts, and shall include the manufacturer's name, trade name, catalogue model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

4 Control System Shop Drawings

- Schematic diagram of each controlled system. Label control points with point names
- Detailed system architecture showing all points associated with each controller, controller locations, and describing the spare point’s capacity at each controller and BMS LAN.

5 Bill of Material for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

6 Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.

7 Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BMS.

8 I/O and Data Point schedule for each PLC’s inputs/outputs showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point.

9 Bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

10 Manufacturer's description and technical data such including product specifications and installation and maintenance instructions for items listed herein:

- Direct digital controllers (BACnet)
- Sensors and Transmitters
- Transducers
- Actuators
- Automatic Control Valves

- Automatic Control Dampers
- Air Flow Sensors/Switches
- Control panels
- Operator interface equipment
- Ancillary equipment such as relays, power supplies and wiring
- Riser diagrams showing control network layout, communication protocol, and wire types.
- Building Automation System Server and Operator Workstation (OWS)
- Central Processing Unit (CPU) or web server (If Required)
- Monitors, Keyboards
- Uninterruptible Power supplies
- Network switches, hubs and routers.
- Interface equipment between CPU or server and control panels
- Operating System software
- Operator interface software
- Colour graphic software
- Third-party software
- Network diagram of control, communication, and power wiring for BMS Server and OWS installation.

3.1.1.16. AS-BUILT DOCUMENTATION (OPERATING and MAINTENANCE MANUALS)

1 As-built documentation shall consist of 4 hard copies and one soft copy for all information described below:-

The final documentation package shall include and be indexed as follows:-

INDEX

A Description of Manual

- Describe the purpose of the manual and what is entails
- Include Design Intent
- Include Control Philosophy (if any)
- Add BMS Contractor Contact Details + Project Number

B Maintenance/Service Contract

- Add Service Contract Details
- Include suggested post 12-month service agreement.
- Guarantees / Warrantees

C Maintenance Manual

- BMS fault management guide (I.e. Alarm Trouble Shooting Guide)
- Maintenance Schedule

D OEM Operation Manual

- Provide Customized User Guide Specific to the installed BMS. (How To Navigate and Operate the BMS)
- Provide a summary of the Buildings system and features.

- Provide BMS Manual

E Asset Register

- BMS PLC's and Data Point List
- Equipment Schedules / Lists
- Suppliers and Contact Details

F Commissioning

- BMS commissioning reports – showing recorded values
- BMS GFX Screenshots with values and set points

G Training

- Training Agenda (see below 'Training')
- Training Certificates & Registers

H As Built Drawings

- System Network Topology + Physical Network Reticulation.
- MCP Wiring Diagrams
- As Built Layouts

I Data Sheets / Specifications

- Peripheral Data Sheets (Indexed)

J Soft Copies

- Full Soft Copy Of Manual
- As Built Backups of all Software, Databases, Graphical Files

2 Each instruction and reference manual shall be bound in hardback, 2 ring, binders or an approved equivalent shall be provided to the Engineer. Binders to be no more than 2/3 full. Each binder to contain index to full volume. One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance. The identification of each manual's contents shall be inscribed on the cover and spine.

3 The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system. The manuals shall have a table of contents and be assembled to conform to the master table of contents with the tab sheets placed before instructions covering the subject. Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph.

3.1.1.17. FINAL ACCEPTANCE

1 Final acceptance shall commence only after satisfactory completion of start-up, verification of performance and the 30-day test period described earlier. When the Contractor has satisfied himself as to proper system operation he shall advise the BMS Commissioning Engineer to establish a date for Final Acceptance. This will involve a random sampling of the point-by-point check of all hardware and software items including graphics and displayed data, as well as performing tasks as directed.

2 Supply 2-way radios and all test equipment as previously specified. Have on-site technical personnel capable of re-calibrating all field hardware and modifying software.

3 Test each system independently and then in unison with other related systems. Test weather sensitive systems twice; once near winter design conditions and again near summer design conditions.

4 Optimize operation and performance of each system.

5 Test full-scale emergency operation and integrity of smoke management and other life safety systems.

6 Demonstrate to the Engineer the operation of each system including sequence of operations in regular and emergency modes, under all normal and emergency conditions, start-up, shut-down, interlocks, and lock-outs.

7 Demonstrate each of the following.

- DDC loop response. Supply graphical trend data output showing each DDC loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
- Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting set point, and status of set points and other affected equipment parameters.
- Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs such as Microsoft Word, Excel or PDF.

8 Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

9 Upon completion of the testing submit a report to the Engineer to summarize all testing.

3.1.1.18. TRAINING

1 The Contractor shall provide the services of competent instructors who will provide instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. The

training shall be oriented towards the system installed rather than being a general "canned" training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The number of person-days (eight hours) of instruction furnished shall be as specified below as a minimum. A training manual shall be provided for each trainee, which describes in detail the data included in each training program.

2 The training program shall be accomplished in two phases.

3 First Phase training shall include the following:

- Review of design intent report.
- Review specific energy efficient feature (electrical / water)
- General BMS architecture (overview)
- System communications (overview)
- Operation of computer and peripherals (overview).
- Operator interface functions for control of HVAC systems (detailed).
- Control descriptive logic (detailed for each system).
- Report generation (overview).
- Alarm Management
- Review of commissioning report and checklists
- OHS issues.
- Maintenance overview, schedules and frequencies.
- How to manage building tuning or tweaking.

4 The second phase of training shall be conducted after system acceptance.

5 The training shall include:

- Equipment Maintenance: This training shall include:
  1. General equipment layout.
  2. Trouble shooting of all BMS equipment.
  3. Preventive maintenance of all BMS components.
  4. Sensors and controls maintenance and calibration.

3.1.1.19. WARRANTY

1 Provide warranty certificates wherever given in excess of the normal warranty period showing the name of the firm giving the warranty, dated from the issuance of the Certificate of Substantial Performance and acknowledged on specific equipment and systems.

2 Include these certificates with the Operation and Maintenance Manual in the appropriate sections.

3 Contractor shall give a minimum one-year warranty for parts and labor on all equipment and materials installed and shall select materials and equipment where the Manufacturer gives the same warranty arrangements. Warranty shall commence on the date of the Engineers issuance of the Certificate of Substantial Completion. If the project is scheduled in multiple contracts or multiple phases of work, each contract or phase shall have a separate warranty start date and period.

4 The Contractor shall agree to make good at his own expense any equipment that fails to operate due to poor workmanship, manufacturing defect or improper

installation. Any repairs shall be made at the convenience of the Engineer during normal working hours, unless deemed an emergency.

3.1.1.20. MAINTENANCE/SERVICE

1 Provide warranty in accordance with the warranty section of this specification. In addition provide scheduled maintenance and service during the warranty period on all control system apparatus including but not limited to direct digital controllers, valves, dampers, linkages, control panels, interfaces, operator workstation, server, software and application programs. Maintenance shall consist of:

- Scheduled preventive maintenance inspections will provide those services required to maintain the system at maximum performance and reliability levels and may include the following:
- Analyse, adjust, calibrate the applicable temperature sensors, humidity sensors, diagnostic LEDs, printers, power supplies, work stations, controllers, modems, input/output points, communication cabling, transmitters, transducers, UPS for the BMS system.
- Conduct inspections and thorough preventive maintenance routine on each piece of covered equipment. In addition, make tests and adjustments to ensure efficient and reliable operation of other major components.
- Examine, clean and calibrate as required sensors, thermostats, humidity controls, temperature controls, pressure controls, relays, damper actuators, instrumentation and accessories directly pertaining to the Building Automation System.
- Check and confirm control system sequence of operation to insure optimum system efficiency and economy.

2 Provide a fully trained BMS service technician as per the agreed frequency during the warranty period to provide the preventive maintenance and service described above. Provide written reports to the owner outlining the work performed.

3 Provide emergency service for parts and labour on an as needed basis. Response to an emergency call shall be 4 hours maximum on Monday through Friday and 8 hours maximum on holidays and weekends.

4 Provide a price for a post service agreement based on the above requirements to come in to effect upon the completion of the warranty period.

3.1.2. SYSTEM / EQUIPMENT SPECIFICATION's

3.1.2.1. PROGRAMMABLE LOGIC CONTROLLERS (PLC'S)

Programmable Logic Controller (PLC) (Primary Systems such as AHU, MAU, Chiller, Boiler, Water System);-

1 Programmable Logic Controller (PLC) shall be microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2 All selected programmable logic controllers or dedicated/specific application logic controllers must support at minimum one of the following communication protocols;-

a) BACnet IP (BTL Certified)

b) BACnet MSTP (BTL Certified)

c) LONworks (Echelon Certified)

d) MODbus

3 The PLC shall feature optional operator interface display that provides real-time access to monitored inputs, set points, modes, values, statuses, and outputs.

4 Each PLC shall have sufficient memory, to support its own operating system and databases, including:

- Control processes
- Energy management applications
- Alarm management applications
- Historical/trend data for points specified
- Maintenance support applications
- Custom processes
- Manual override monitoring

5 Each PLC shall support:

- Monitoring of the following types of inputs, without the addition of equipment outside the Controller cabinet:
- Analog inputs of 4-20 mA, 0-10 Vdc, 10K thermistor, 1K ohm RTD, NI1000.
- Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
- Each PLC shall be capable of providing the following control outputs without the addition of equipment outside the controller cabinet:
- Digital outputs
- Analog outputs of 4-20 mA or 0-10 Vdc.

6 Each PLC shall have a minimum of 10% spare capacity for each point type for future point connection. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. As a minimum, provide one of each type of point available on the controller.

7 Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

8 The PLC shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

9 Should the PLC memory be lost for any reason, the user shall have the capability of reloading the controller software via the BMS LAN OWS or Server.

10 Controllers shall include all point inputs and outputs necessary to perform the specific control sequences. As a minimum, 25% of the point outputs shall be of the universal

type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators.

11 Each controller shall perform its primary control function independent of other PLC's, OWS or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the OWS controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings.

12 All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

13 PID control loop tuning shall form part of the post-commissioning process and stable output response must be demonstrated.

3.1.2.2. HUMAN MACHINE INTERFACE (HMI)

1 A mountable easy to operate User Interface that provides direct read / write access to any point on the network. The LCD Display shall provide the following:

- The Display shall consist of an alphanumeric LCD display, and a multi-function keyboard.
- The Display User access shall be through a simple to use directional and entry buttons. Full keyboards shall be accepted

2 The LCD Display shall be provided as a surface mount or flush mount as shown on the mechanical drawings.

3.1.2.3. CONTROL PANELS, ENCLOSURES & SUB-PANELS

In addition to the General Technical Specification the contractor shall comply to the below:-

1 Provide wall or base mounted enclosures to house all controllers, transformers, relays, etc. associated with system, mechanical room or area.

2 Enclosures shall conform to the following requirements:

- Enclosures located in wet indoor conditions or located outdoors shall meet IP55 Rating Complete with weather shield.
- Enclosures located in all other locations including but not limited to mechanical or electrical rooms, occupied spaces, above ceilings and plenums

shall be IP 44 classification, except if location requires additional protection due to potential vandalism or environmental conditions and shall at a minimum meet IP55 requirements.

- Provide a continuous piano hinged door, keyed locking latch and removable sub-panel. A single key shall be common to all control enclosures.
- Provide each DDC panel with on/off control, 240VAC convenience outlet, high/low voltage separation, control fuse(s), control transformer(s), terminal blocks and power supplies as necessary.
- Motor control panels shall comply with SANS1473-1 and SANS/IEC 60439.
- Panels Housing Variable Frequency Drives shall be force ventilated, complete with changeable dust filter.
- Chassis and cable trunking shall be adequately sized as not to result in overcrowded or densely populated wire trunking.
- All Panels shall ensure a 20% free space capacity is maintained for future or additional addendums to the panels.

3.1.2.4. CONTROL WIRING AND RACEWAYS

1 Control and interlock wiring and installation shall comply with national and local electrical codes (SANS) and manufacturer's recommendations. Where the requirements of local electrical codes differ from manufacturer's recommendations, local electrical codes (SANS) shall take precedence.

2 Under no circumstance will cable joins be accepted, continues cable runs from point to point must be maintained.

3 Control wiring shall not be installed in proximity of minimum 1 meter of medium or high voltage cabling or raceways.

4 Network communication wiring shall be installed in shielded conduit and earthed at one point and shall be sufficiently protected against electromagnetic interference.

5 Provision shall be taken to ensure wiring exposed to the elements is either sufficiently UV rated and or installed in galvanized conduit.

6 Raceways / trunking shall be sufficiently sized to cater for required amount of cabling to be carried whilst maintaining minimum 30% free capacity. Overcrowding of raceways, trunking and conduits will not be accepted.

7 Boxes and panels containing high-voltage wiring and equipment shall not be used for low/extra low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

8 Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

9 Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

10 Use color-coded conductors throughout.

11 Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

12 Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.

13 Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

14 Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

15 Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

16 Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

3.1.2.5. IDENTIFICATION OF HARDWARE AND WIRING

1 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

2 Permanently label or code each point of field terminal strips and panel wiring terminals to show instrument or item served.

3 Label control panels with minimum 1 cm (½ in.) letters on engraved phenolic labels installed in aluminium cradle mounted to panel door.

4 Label each control component with a permanent label. Label plug-in components such that label remain stationary during component replacement.

5 Label room sensors related to terminal boxes or valves with nameplates.

3.1.2.6. ACTUATORS

1 Electronic Damper Actuators shall have the following characteristics:-

- Size for torque required for damper seal at load conditions.
- Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
- Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.
- Fail-Safe Operation: Mechanical, spring-return mechanism. Internal chemical storage systems, capacitors, or other internal non-mechanical forms of fail-safe operation are not acceptable.
- Power Requirements (Two-Position Spring Return): 24 or 240 VAC as required.
- Power Requirements (Proportional): Maximum 10 VA at 24 VAC or 8 W at 24 VDC.

- Temperature Rating: -22 to +122°F (-30 to +50°C)
- Housing: Minimum requirement NEMA type 3 / IP54 mounted in any orientation

2 Electronic Valve Actuators shall have the following characteristics:-

- Size for torque required for valve close off at 150% of total system (head) pressure for 2-way valves; and 100% of pressure differential across the valve or 100% of total system (pump) head differential pressure for 3-way valves.
- Coupling: Directly couple end mount to stem, shaft, or ISO-style direct-coupled mounting pad.
- Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to deactivate the actuator at the end of rotation.
- Fail-Safe Operation: Mechanical, spring-return mechanism. Internal chemical storage systems, capacitors, or other internal non-mechanical forms of fail-safe operation are not acceptable.
- Power Requirements: Maximum 10 VA at 24 VAC or 8 W at 24 VDC.
- Temperature Rating: -22 to +122°F (-30 to +50°C)
- Housing: Minimum requirement NEMA type 3 / IP54 mounted in any orientation.

3.1.2.7. AUTOMATIC CONTROL VALVES

1 Unless otherwise indicated, hydronic system two and three-way automatic control valves shall be globe-style bodies and have the following characteristics:

- Bronze body, stainless steel stem, stainless steel plug, stainless steel seat.
- Flow Characteristics: Linear or equal percentage characteristics.
- Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 150% of the design pressure differential across the 3-way valves.
- Bodies for valves 3” to 6” shall be iron, cast iron or cast steel with flanged connections and shall be rated. Packing shall protect against leakage at the stem.
- The Valve shall be capable of tight shut-off when operating at system pressure with the system pump operating at shut-off head. Leakage rate shall not exceed 0.01% of the rated valve capacity.
- The Actual valve kvs values shall not deviate from the quoted kvs value by more than +10%.
- The Valves shall be selected in such a way that the valve authority (N) shall not be less than 0.5 as defined by the relationship:
    - N = P1I(P1+P2) where
    - P1 = pressure drop across the fully open valve, and
    - P2 = pressure drop across the remainder of the circuit (e.g. a coil, DRy, isolation valves, strainers)

2 Where specified, butterfly control valves shall adhere to the following:

- Valve body shall be cast iron with a stainless steel disc, shaft and EPDM seat.

3 Zone Valves (On/Off, Two-Position Applications):

- NPS 1 and Smaller: Forged brass body rated at no less than 300 psi, stainless steel stem, female NPT union or sweat with a stainless steel stem and EPDM seals.
- Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 125% of the design pressure differential across the 3-way valves.

4 The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory.

5 Note: Valves selected to operate below 0ºC must include stem heating elements to prevent ice buildup.

3.1.2.8. SENSORS / SWITCHES

1 All electric switch devices shall be selected for the applied load and for the application and environment to which they are applied. Miscellaneous, electric, and mechanical devices shall include:

- Safety high limit controllers shall be manual reset type when provided in the ducts and pipes where the anticipated temperature, humidity or pressure could exceed normal operating parameters and cause equipment damage and/or a life safety situation. Provide temperature, humidity and pressure high limit controllers where indicated on the drawings and as necessary to protect equipment and occupants.
- Temperature safety low limit controllers shall be manual reset type with a twenty-foot liquid filled capillary responsive to the coldest one-foot section of its length. Provide temperature, humidity and pressure low limit controllers where indicated on the drawings and as necessary to protect equipment and occupants.
- Duct smoke detectors shall contain an air-sampling chamber with sampling tubes extending through the width of the air duct. Alarm status indicating lights shall be visible on the front of the detector. Duct smoke detectors shall be supplied and installed by Division 16. The controls contractor shall wire to the auxiliary contact of the duct smoke detectors to monitor its status.

2 Input/output sensors and devices shall be closely matched to the requirements of the BMS controller for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

3 Sensors and transmitters shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.

4 Provide guards (plastic or wire) for sensors, thermostats, controllers and transmitters that are installed in public areas such as gymnasiums, classrooms, corridors, and vestibules.

5 Space temperature sensor shall consist of an element within a ventilated cover.

6 Duct temperature sensors shall be rigid stem or averaging type as specified in the sequence of operation.

7 Duct temperature sensor shall consist of steel sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.

8 Outdoor air temperature sensor shall consist of a single device sensor, ventilated sun shield, junction box for terminations, and watertight gasket.

9 Averaging duct temperature sensor shall consist of a copper or stainless steel averaging element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.

10 Liquid Immersion temperature sensor shall consist of a stainless steel sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Provide and turn over to the mechanical contractor a stainless steel thermowell for each immersion sensor provided.

11 Provide humidity transmitters as indicated in the drawings and/or specifications. Humidity transmitters shall be suitable for space, duct or outside mounting and consist of a capacitive type humidity sensing element and microprocessor temperature compensation for accuracy of +/- 2% relative humidity over the range of 10 to 90% relative humidity.

12 Outside air type humidity transmitters shall be provided with a junction box for terminations, and watertight gasket.

13 Duct type humidity transmitters shall come complete with sampling chamber and a junction box for wiring connections and gasket to prevent air leakage or vibration noise.

14 Space type humidity transmitter shall be provided with a ventilated cover.

15 Provide Pressure Sensors as indicated in the drawings and/or specifications. Static Air Pressure Sensor shall have linear output voltage or current signal. Zero and span shall be field-adjustable.

16 The pressure sensor for air applications shall provide a linear output signal. The device shall be capable of measuring positive, negative or differential pressure in the ranges of 1 inch of WC to 12 inches of WC with over pressurization to 20 PSI without a zero-shift and shall have field adjustable zero and span. The assembly shall consist of pressure connections that secure pressure sensor to a housing for duct or remote mounting. Connect transmitter to pitot tubes ensuring a minimum length of 6 inches.

17 Water Differential Pressure Sensors shall be field selectable pressure range and output signal type. Sensors shall accept ranges from 5 PSI to 500 PSI with over pressurization to two times the maximum full scale range and burst pressure to fifteen times the maximum full scale range. For water shall consist of a differential pressure tap secured to a stainless steel diaphragm and an electronic sensor enclosed in a gasketed, dust and watertight case.

18 Steam and water gauge pressure sensor shall include connections secured to a stainless steel diaphragm sensor with a gasketed, dust and watertight housing for remote mounting. Incorporate a “pig-tail” connection in the installation so as to protect the sensor. Use snubbers to prevent system pressure hammers and surges from being fully transmitted to the pressure sensor.

19 Carbon Dioxide sensors shall use non-dispersive infrared technology. CO2 sensors shall come in a range of 0-2000 ppm and an accuracy of +/- 50 ppm or +/- 3%. Sensors shall be available for both duct and wall applications.

20 Indoor Air Quality sensors shall use a tin dioxide semiconductor sensor to detect oxidize-able gases to measure volatile organic compounds (VOCs) in ppm. Sensors shall be mounted as indicated on the drawings.

21 Carbon Monoxide detector shall utilize electrochemical sensing elements and be available in a range of 0-500 ppm and an accuracy of 3%.

22 Air Flow Monitoring Stations shall be a solid state electronic device comprised of a thermistor based sensing grid and microprocessor based electronics panel for flow averaging, temperature compensation and signal transmission. The air flow monitoring stations shall connect to the BMS via a 4-20 mAmp or 0-10 Vdc signal.

23 Dew point sensors shall employ a non-reactive organic bobbin material to give precise dew point readings with error of no more than + or - 1.5 degrees. The dew point sensor shall incorporate an integral draft shield as part of the instrument for air velocities in excess of 50 feet per minute.

24 Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

25 Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

26 Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless-steel meter body, maximum error of no more than .5% of span, and 4 to 20 ma output. Sensor shall be rated for 250 psi minimum and installed in strict accordance to the manufacturer's instructions complete with three-valve manifold for calibration and maintenance.

27 Kilowatt transducers shall be the integrated electronic type with accuracy of .2% of scale. For balanced (such as motors) three phase loads, two current transformers (CTs) shall be provided and for unbalanced loads, three CTs shall be provided. Two or three potential transformers (PTs) shall be provided as recommended by the manufacturer for the application.

28 Analog output transducers shall be designed for precision closed loop control with pneumatic repeatability error no greater than 1%.

29 Current sensing relays used for proof-of-loading for fans and pumps shall be suitable for 2 to 200 amperes and shall have adjustable trip thresholds of plus or minus two percent of range. Each relay shall be provided with an LED to allow ready observation of the relay status.

30 Fan proof-of-flow switches shall be adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WC, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WC.

31 Pump proof-of-flow switches shall be adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 250 psi body. Differential pressure switches shall have valve’d manifold for servicing.

3.1.2.9. WATER ENERGY, FLOW & CONSUMPTION METERS

Chilled / Hot Water Energy Meters

1 Chilled Water Energy Meters as described in this specification shall be equal and approved to **SIEMENS, HONEYWELL, KAMSTRUT OR ENDRESS & HAUSER** manufacture and shall be installed in the positions as indicated on the drawings.

2 Chilled Water Energy Meters are to be supplied as a combined package including a flow meter, an integrator or calculator with temperature sensors for the management and billing of energy or chilled water consumption within the air-conditioning chilled water system.

3 The integrator shall measure the temperature difference and the volume through two immersion type sensing elements, and a flow meter. A microprocessor in the integrator unit determines the temperature differential which the microprocessor uses, along with the average flow rate and the specific heat capacity, to calculate the amount of cooling energy consumed.

4 Energy Meters should comprise of one of the following methods of chilled water flow measurement unless otherwise specified or indicated in the Detailed Technical Specification or on the Drawings:

- Ultra-Sonic Flow Meter
- Magnetic Flow Meter
- Ultra-Sonic Flow Meters

5 The Ultra-Sonic Flow Meter shall measure the flow of the water using the dual directional transit-time method. The device should consist of two Ultra-Sonic transducers that are used to send signals in two opposite directions, against and with the flow. The device should use the principal of time difference, converting the traveling time difference between the two signals into a flow velocity and thus a volume.

6 The Ultra-Sonic Flow Meter shall be of the in-line flanged or screwed type and should allow for servicing of the transducers and other components without the need for interrupting or stopping the flow of the Chilled Water. The Ultra-Sonic Flow Meter should also not require re-calibration or re-setting after minor servicing.

7 The meter shall also provide automatic Reynolds Number and liquid sonic velocity variation calculations and corrections.

8 Equipment that only makes use of the Doppler method of flow measurement will not be accepted. Flow meters that employ the use of a single transducer will also not be accepted

9 The flow meter shall have an accuracy of +/- 0.5-1% of the flow over a +/- 15m/s range. The meter should have a flow sensitivity of 0.01m/s at any flow rate including no flow conditions.

Consumption Meters

10 The Consumption flow meters are to be hydraulic impeller type and flow rate value is transferred to a mechanical totalizer via a magnetic clutch.

11 The meter is to include a mechanical or digital local totalizer display.

12 The meter must include a flow check protection.

13 Remote Reading Output functionally (if not specified by engineer, allow most stringent);-

- Reed Contact completed with NAMUR circuitry
  - Pulse / Consumption ratio must be noted on meter.

- M-Bus Protocol

  - M-bus system for remote readout, remote operation and supervision of consumption meters. The M-bus central unit is to be connected to a BMS or automated control system.
  - The M-bus system should offer a minimum of the following remote functions:

    - Device identification through an automatic search run.
    - Remote operation of plant with the PC, via modem or a direct connection.
    - Acquisition of consumption data.
    - Remote readout of consumption via display on the M-bus central unit or the PC.
    - Visualization of plant diagrams.
    - Recording and graphic presentation of processes.
    - Remote detection of faults and malfunctions and display of appropriate alarms.
    - Status reports.
    - General Energy Meter Requirement

14 The Energy Meter must comply with the British standard EN1434.

15 It is the Air Conditioning Sub-Contractors responsibility to supply the manufacturer with all possible flow parameters; maximum, minimum or zero flow, associated with the particular installation so an accurate model selection can be made by the manufacturer.

16 All equipment offered should comply to a pressure test class of PN 16.

17 Materials used in the construction of the Flow or Temperature measuring modules should not be of any kind that may lead to corrosion of any equipment used within the Chilled Water Air-conditioning system. The meter should be housed in an IP65, flame retardant, cast aluminum or fiberglass reinforced polyester housing or similar. After commissioning the housing should have the facility to be made tamper proof so no post commissioning or unwanted adjustments can be made.

18 The complete Energy Meter should be able to operate in ambient conditions of a maximum temperature of 55degC and Relative Humidity of 85%.

19 The meter should have at least three display levels which show the following values and variables:

- Cumulated cooling energy consumption since the last set day.
- Segment test.

- Actual heat and cooling output.
- Actual flow temperatures.
- Actual return temperatures.
- Actual temperature differential.
- Meter's number of operating hours since it was first installed.
- Set day and set month.
- Stored cooling energy consumption of previous year.
- Stored cooling energy consumption of the last 12 months.
- Cumulated cooling energy consumption since the meter was first installed.
- Indication of faults.

20 The integrator should have a permanent memory feature that logs all data as mentioned above in the event of a power failure, including battery failure.

21 The temperature sensors are to be immersion type sensors. They are to be immersed either indirectly or directly. The sensors should consist of an immersion rod the end of which carries the sensing element, a threaded nipple and an appropriate waterproof cable connection to the integrator or calculator.

22 The electrical and electronic equipment shall be of good quality. The meter should meet specifications without requiring re-calibration or change of components during the first 8 years of operating life.

3.1.3. MANAGEMENT SYSTEM SPECIFICATION

3.1.3.1. OPERATOR WORKSTATION HARDWARE

OPERATOR WORKSTATION

1 Hardware requirements of the Server, Operator WorkStation (OWS) and Portable Operator Workstation are specified in this section:-

2 General Description: The OWS shall consist of commercially available general-purpose equipment manufactured by a recognized manufacturer with factory authorized service centers within 100 km of the job site. Acceptable manufacturers are Lenovo, DELL, HP or MECER. The OWS shall be provided for centralized system control, information management, alarm management and data base management functions. All real time control functions shall be resident in the standalone Network Control Unit (NCU) and local controllers (LCUs and TCUs).

3 Provide Server and Operator workstations as detailed herein. Provide software at OWS and/or on the server. Provide Web Browser Clients software on Portable.

4 The system shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users. The BMS shall be provided with a minimum of 32 user licenses.

5 Any computer on the BMS LAN shall be capable of displaying the systems in a graphical and dynamic format utilizing a standard web browser. Screen refresh shall be automatic. Manual refresh is not acceptable.

SERVER HARDWARE REQUIREMENTS

1 The Server shall be a PC with minimum:-

- Core i5 processor or equivalent
- GB RAM
- 250 GB hard drive providing data at 100 MB/sec.
- Super Multi SATA Drive
- 1-asynchronous serial port
- 4-USB ports.
- 2-HDMI Output
- Minimum 22”, HD LED color monitor with a minimum 80 Hz refresh rate .23

2 The server operating system shall be Microsoft Windows 8 with the most recent service packs. Include the most recent version of Microsoft Internet Explorer and Microsoft Office.

3 Connection to the BMS LAN network shall be via an Ethernet network interface card, 100 Mbps.

4 The server shall support all Network Control Units (NCU), OWSs, and party mechanical / electrical systems connected to the Facility Management Control/ Building Automation System Local Area Network.

5 The server shall be Lenovo, DELL, HP or MECER manufactured.

WORKSTATION HARDWARE REQUIREMENTS

1 The Workstation shall be a PC with minimum:-

- Core i5 processor or equivalent
- GB RAM
- 250 GB hard drive providing data at 100 MB/sec.
- Super Multi SATA Drive
- 1-asynchronous serial port
- 4-USB ports.
- 2-HDMI Output
- Minimum 22”, HD LED color monitor with a minimum 80 Hz refresh rate

2 The workstation operating system shall be Microsoft Windows 8 with the most recent service packs. Include the most recent version of Microsoft Internet Explorer and Microsoft Office.

3 Connection to the BMS LAN network shall be via an Ethernet network interface card, 100 Mbps.

4 The server shall be Lenovo, DELL, HP or MECER manufactured.

WORKSTATION HARDWARE REQUIREMENTS (NOTEBOOKS)

1 The Notebook shall be a PC with minimum:-

- Core i5 processor or equivalent
- GB RAM
- 250 GB hard drive providing data at 100 MB/sec.
- Super Multi SATA Drive
- 2-USB ports.
- 1-HDMI Output
- Embedded 10/100TX Ethernet, 802.11 b/g/n Wireless LAN and Bluetooth 4.0
- Minimum 15.4', HD Screen

2 The notebook operating system shall be Microsoft Windows 8 with the most recent service packs. Include the most recent version of Microsoft Internet Explorer and Microsoft Office.

3 Connection to the BMS LAN network shall be via an Ethernet network interface card, 100 Mbps.

4 The server shall be Lenovo, DELL, HP or MECER manufactured.

5 Turn over the notebook workstations to the owner at time of training.

PRINTERS

1 The report/alarm printer shall be connected to each Operator Workstation in the Engineer's office.

2 The report/graphics/alarm printer shall be a colour inkjet printer, 1440 x1440 dpi photo quality colour resolution, internal 1MB buffer memory, minimum 8 pages per minute in black and 4 pages per minute in colour, 100 sheet 8.5"x11" cassette feed, 100 sheet output cassette, with separate dedicated colour and black and white cartridges. Supply one spare set of ink cartridges and 5000 sheets of paper.

UNINTERRUPTABLE POWER SUPPLIES

1 UPS shall provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration. Approved UPS manufacturer

3.1.3.2. OPERATOR WORKSTATION SOFTWARE

1 The software shall be capable to employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

2 Real-Time Displays. The OWS, shall at a minimum, support the following graphical features and functions:

- Graphic screens shall be developed using GIF, PNG, JPG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
- Graphic screens shall have the capability to contain objects for text, real-time values, animation, colour spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
- Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
- Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
- Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
- Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analogue objects, such as set points. No entry of text shall be required.

3 System Configuration. At a minimum, the OWS shall permit the operator to perform the following tasks, with proper password access:

- Create, delete or modify control strategies.
- Add/delete objects to the system.
- Tune control loops through the adjustment of control loop parameters.
- Enable or disable control strategies.
- Generate hard copy records or control strategies on a printer.
- Select points to be alarm-able and define the alarm state.
- Select points to be trended over a period of time and initiate the recording of values automatically.

4 On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

5 Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

6 System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciate to the operator.

7 Alarm Console. The system shall be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

8 Operator's workstation software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming. This system shall provide the capability to configure controller binary and analogue inputs/outputs.

9 The system shall be capable of utilizing third-party Windows-based programs for such things as spread sheets analysis, graphing, charting, custom report generation, and graphics design packages. Graphics generation shall be done using standard Windows packages. No proprietary graphics generation software shall be needed.

10 Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

11 The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information. All requests for status, analogue, graphic displays, logs, and control shall be selected from the operator's console. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection. The facility shall be provided to permit the operator to perform the following tasks:

- Automatic logging of digital alarms and change of status message.
- Automatic logging of all analog alarms.
- System changes (alarm limits, set-points, alarm lock-outs, etc.).
- Display specific points as requested by the operator.
- Provide reports as requested by the operator and on Scheduled basis where so required.
- Display graphics as requested by the operator.
- Display help information.
- Provide trend logs as required by the operator.
- Provide manual control of digital and analog outputs as required by the operator.
- Direct the hard copy output of information to the device selected by the operator.
- Data displayed on monitor to cyclic update as appropriate.

12 Online changes Functionality:

- Alarm limits
- Setpoints

- Deadbands
- Changes/deletions/additions of points.
- Control and change of state changes.
- Time of day, day, month, year.
- Control loop control description changes for NCU based CDM's
- Control loop tuning changes
- Schedule changes
- Changes/additions/deletions to system graphics
- Changes/additions/deletions to total systems

13 It shall be possible for the OWS operator to initiate analog and digital output commands. Where the BMS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BMS control of any particular output and to originate a manual analog or digital output command. The provision shall exist for the operator to return analog or digital output command functions to automatic BMS software control.

14 It shall be possible for the OWS operator to place any computed system setpoint to a computed basis as and when required.

15 All above functions shall operate under the password protection system.

16 Engineering units shall be applied to analog input and output points. Typical description is as follows: %, DegC, KPA, KW, KWH, L/S, CFM, DegF, and PSI.

17 Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on printer or screen. The output device shall be by operator's choice. Analog values and status displayed on the screen shall be updated whenever new values are received. Points in alarm shall be flagged by blinking, inverse video different colour, bracketed, or by some other means to differentiate them from points not in alarm.

ERROR MESSAGES

1 Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of BMS.

2 Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

PASSWORD PROTECTION

1 Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator’s terminal functions unless user is logged on. This includes displays as outlined above.

2 Each operator’s workstation shall provide security for 50 users minimum. Each user shall have an individual User ID, User Name and Password. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator’s terminal. Each user shall also have a set security level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.

TREND DATA

1 System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk. Archived files shall be appended with new sample data, allowing samples to be accumulated over several years. Systems that write over archived data shall not be allowed, unless limited file size is specified. Samples may be viewed at the operator's terminal in a trend log. Logged data shall be stored in spread sheet format (csv). Operator shall be able to scroll through all trend log data. System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. All trend log information shall be displayed in standard engineering units.

2 Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours. Graphs shall show object type value relative to time.

3 Operator shall be able to change trend log setup information as well. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics object is displayed on.

4 System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed unless limited file size is specified. System shall automatically open archive files as needed to display archived data when operator scrolls through the data. Display all energy log information in standard engineering units.

5 System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time. All data shall be stored in comma-delimited file format for direct use by third-party spread sheet or other database programs. Operation of system shall not be affected by this operation. In other words, it shall stay completely online.

6 Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. All operations shall be password protected.

GRAPHICS

1 The operator's workstation shall display all data associated with the project. The operator's terminal software shall accept, GIF, PNG, JPG and ICO format graphic files for display purposes. Graphic files shall be created using scanned, full colour photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's terminal shall have the capability to display all data using 2-D or 3-D graphic representations of all mechanical equipment.

2 System shall be capable of displaying graphic file, text, and dynamic object data together on each display. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Terminal shall allow user to change all field-resident BMS functions associated with the project, such as set points, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

3 All displays shall be generated and customized in such a manner by the local DDC system supplier that they fit the project as specified. Canned displays shall not be acceptable. Displays shall use Standard English for labelling and readout. Systems requiring factory programming for graphics or DDC logic are specifically prohibited. The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.

4 Binary objects shall be displayed as ON/OFF or with customized text. Text shall be justified left, right or centre as selected by the user. Also, allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp). Additionally, allow binary objects to be displayed as an animated graphic.

5 Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change bitmap file assignment and also create new and original bitmaps online. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator. Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed, unless specifically approved by the engineer.

6 Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trend logs.

7 Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value. For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.

8 A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A separate security level may be assigned to each display and system object.

9 A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

10 Displays may be modified on site or via remote communications.

11 Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

ALARMS

1 Operator’s terminal shall provide audible, visual, and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s), currently running (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.

2 System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

3 Alarm messages shall be in user-definable text English or other specified language) and shall be entered either at the operator’s terminal or via remote communication.

SCHEDULING

1 Operator’s terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule. This includes all ON/OFF times (to the minute) for each day’s events.

2 Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules. These speciality schedules shall be displayed at the operator’s terminal in a format similar to the weekly schedules, again allowing easy data entry. Exception schedule data is entered by the following methods: date entries (one day entries), date-to-date (a range or span of days), and by weekday (for example, a given day of a given week each month). User shall be able to scroll easily through the months for each year as a minimum.

3 At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

ARCHIVING

1 Store back-up copies of all controller databases in at least one OWS and/or the server.

2 Backups of the 'As Built' controller and BMS workstation/server databases shall be provided to the owner on a CD

3 Provide continuous supervision of integrity of all controller databases. If controller loses database, system to automatically download new copy of database to restore proper operation.

4 Data base back up and downloading to occur over LAN without operator intervention. Operator to be able to manually download entire controller database or parts thereof.

REPORTS

1 Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section. If display output (screen) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report. Output to be sorted by area, system point.

2 Periodic/Automatic Report: Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device. The software will allow the operator to modify the periodic/automatic reporting profile at any time.

3 As a minimum, the following reports shall be configured on the system:

- Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency. It shall be possible to select points on the following basis:
    - All points in all areas
    - Area (all points in area)
    - Area system (all points in system)
    - Area system point (individual point)
    - System (all points by system and point type)
    - System point (all points by system and point type)
    - Area point (all points by area and point type).

4 Summary Report: To permit the display or printing the dynamic value for the user specified points which shall indicate the status at the time the CLM was entered. Reports to be available on same basis as dynamic reports. Output will be to the user selected output device.

5 Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

6 Historical Data Collection: Provision shall be made to ensure historical data is not lost. The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided. Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.

7 Critical Alarm Summary: Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.

8 Maintenance Alarm Summary: Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.

9 Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

10 Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

11 Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

12 Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

13 User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

UTILITY SOFTWARE

1 Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.

2 Enter all soft copy submissions; including "Record" drawings as specified herein [Shop Drawings, Product Data and Review Process] in OWS.

WEB BROWSER CLIENTS

1 The primary means of access to the BMS for day to day operation from any PC connected to the LAN (and or remote via the Internet if so required) without the need for any proprietary software.

2 The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Mozilla Firefox™. Systems requiring additional software (to enable a standard Web browser) to be resident on

the client machine, or manufacture-specific browsers shall not be acceptable. As a minimum provide the capability of 32 web browser clients that can simultaneously access the system.

3 The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the Building Management System (BMS), shall not be acceptable.

4 The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

5 The Web browser client shall support at a minimum, the following functions:

- User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and or encryption techniques to prevent unauthorized access shall be implemented.
- Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
- HTML programming shall not be required to display system graphics or data on a Web page
- Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

6 Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

3.1.3.3. SOFTWARE LICENSE AGREEMENT

1 The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project. Any and all required User IDs and passwords for access to any component or software program shall be provided to the owner.

3.2. ELECTRICAL WIRING

1 Electrical wiring shall comply fully with the B.S. Code of Practice for the Wiring of Premises and the additional requirements of the local authorities who have

jurisdiction over the Site of Works, as well as being in accordance with best modern practice.

2 Main power incomers to plant rooms will be provided by others, excluding making-off of cables within the electrical switchpanels provided by the air conditioning Sub-contractor who shall attend upon and liaise with whoever brings power cabling to his switchpanels.

3 Conduits shall be galvanised to B.S. specification. All joints shall be screwed. No conduit less than 20mm shall be used. Conduit fittings and boxes shall be of galvanised iron to B.S. specification.

4 Galvanised conduits and conduit fittings shall be installed in positions exposed to weather, or in moist surrounding. Where galvanising has been removed by threading, cutting, etc., the exposed parts shall be suitably treated with cold galvanising to render them weatherproof and rust resistant.

5 Conduit shall either be screwed and locknutted on both sides, and bushed on the inside of the box or appliances in which it is terminated. Only solid brass bushes shall be used. Alternatively, and particularly in distribution boards, conduits shall be terminated with couplings and brass male bushes.

6 Conduit in roof spaces shall be run parallel and at right angles to roof members and shall be secured to these members by means of saddles and screws.

7 No conduit is to cross an expansion joint in the structure without an approved arrangement for crossover. Where details of the crossover are not given, the Sub-contractor shall refer to the Engineer for instructions.

8 The Sub-contractor shall notify the Engineer in good time before any conduits in concrete are covered so that tubing may be inspected and checked before concrete is cast, and shall attend on the Engineer during such inspections.

9 Conduit for future requirements shall be terminated with boxes and overlapping cover plates, and fitted with galvanised steel draw-wires. Where such conduit terminations project from the wall or slab, they shall be fitted with couplings and plugs. Such terminations in exposed positions shall be sealed with bitumen and protected with weatherproofing paint.

10 Inspection facilities shall be provided as specified by B.S.

11 Exposed conduits shall be fitted with steel saddles of same finish as conduits pitched at centres not exceeding 2 meters.

12 Conduit boxes to be cast in concrete shall be secured to shuttering by means of 5mm screws and nuts, unless some other method of fixing is approved by the Engineer.

13 Draw boxes and blank boxes in R.C. slabs, columns or in walls shall be fitted with substantial oversized metal cover plates, fixed with countersunk screws, before surrounding surfaces are painted. Draw box positions must be approved and care shall be taken that they do not affect the appearance of the building adversely. Where possible a single cover plate shall be fitted for a number of adjacent draw boxes.

14 Draw boxes in roof spaces which are only accessible above ceilings shall not be installed in positions where clearance from ceiling to roof is less than 1 meter.

15 Blank switch and plug boxes shall be fitted with blank cover plates and screws to match those specified for switches and switch sockets.

16 Mounting heights of boxes shall be as indicated on the Drawings which shall refer to the distance between the centre of the outlet box and the finished floor level, unless otherwise specified or indicated. Where two similar outlets occur adjacent to each other, these shall line up accurately horizontally, unless otherwise indicated.

17 When chasing of brickwork is carried out by the Sub-contractor due care shall be taken to prevent damaging of walls during chasing. He must ensure that other trades are not held up owing to delays in such work. Damage to brickwork will be made good by the building contractor.

18 Under no circumstances is face brick or other finished surfaces to be chased without the permission of the Engineer.

19 Where it is necessary to chase structural concrete, the permission of the Structural Engineer must first be obtained. Where this is not done and the structure is chased without permission, the Sub-contractor will be held responsible for any damage to the structure which may be caused.

20 All wiring shall, unless otherwise specified, be carried out with P.V.C. insulated cable to B.S.

21 Plastic insulated (P.V.C.\S.W.A.) cables shall be to B.S. and addenda thereto and shall consist of P.V.C. insulated conductors, P.V.C. beddings, galvanised steel wire armouring and a P.V.C. sheath.

22 P.V.C.\S.W.A. Cable ends shall be made off with approved glands. The glands shall be of the type in which the armouring is clamped between tapered cones compressed by the action of a screw and in which the gland is secured to the outlet casing by means of screwing and-or locknutting.

23 Neoprene shrouds shall be used to cover the junction of the cable and the base of the gland.

24 The wiring in all Plant rooms shall be supported on cable trays or in cable ducts.

25 Cable supports for single or not more than a group of three cables shall be equal to **UNISTRUT** die-cast cable cleats with **UNISTRUT** type P-1000 channel fixed to walls or overhead slab at not exceeding 600mm pitch. Cables supported in this manner shall be properly straightened and neatly run to the full satisfaction of the Engineer.

26 Cable trays shall be run strictly horizontal or vertical planes, any change of level however, being done with a 45° slope. Where cables leaving trays drop down to equipment, use minimum tray width of 150mm and two vertical **UNISTRUT** supporting channels fixed to horizontal tray at top and floor at bottom.

27 All earthing shall be carried out in accordance with wiring regulation, earthing connections being executed with appropriate copper earthing strip using brass bolts, nuts and washers to ensure continuity to main building earth provided by others.

28 Each run of P.V.C.\S.W.A. multi-core cable shall carry an additional conductor to be used for earth continuity and properly made-off for this purpose.

29 Connections to vibrating equipment shall be made with metal sprague on conduited systems, a separate earth continuity conductor being run outside the flexible conduit.

30 On cable systems, leave sufficient cable slack to allow free cable movement to take up vibration.

31 All connections to vibrating equipment shall be made so as not to impose strain on conduits, cables, conductors or equipment and shall be of sufficient length to allow full adjustment of motors on slide rails.

3.3. SWITCHPANELS, MCP AND CONTROL BOARDS

1 Provide and install, in the positions indicated on the Drawings, switchpanels and control boards complying in operating principals with the automatic control sequence as described before. The panels & switchboards shall be equal to ABB or approved equal.

2 Before commencing with the manufacture and wiring of the switchpanels and control boards the Sub-contractor shall submit three copies of up-to-date Wiring Diagrams, schematic ladder type Diagrams of the control systems and dimensioned panel layout Drawings to the Engineer for approval. All Drawings shall show the correct terminal numbers and wire identification numbers to be used.

3 The Engineer shall be informed of all modifications to the wiring made until the end of the guarantee period and updated drawings shall be submitted immediately after each modification is made.

4 The complete electrical installation and all electrical equipment and material covered under the Sub-contract shall comply with the latest edition of the BS. Code of Practice. The workmanship and installation shall comply with the B.S. Code of Practice, Local Municipal Regulations and Bye Laws.

5 All components of a similar nature shall be of one make with corresponding parts being interchangeable. All equipment shall be of robust construction and have ample ratings for the duties imposed.

6 The System Fault Levels for which the switchpanel components shall be designed and selected shall be 10KA, or as otherwise noted in Part V of these Specifications, for each switchpanel and control centre.

7 All equipment in the switchpanels such as fused switches and moulded case circuit breakers, controlling outgoing circuits, shall be rated accordingly.

8 Switchpanels and control boards shall be of the floor mounted type for panels having a total face area in excess of 1,2 m^2, and wall mounted if less than 1,2 m^2. Where switchpanels exceed 1,2 meters in length they shall be divided into multi-sections.

9 Switchpanels shall be arranged for front access only and bottom cable entry with the main incoming isolators positioned on the extreme left hand side of each switch panel. All switchpanels shall be arranged for top exit via cable ducts.

10 When starting equipment creates higher than normal ambient temperatures the switchpanels shall be adequately ventilated by means of splash-proof top ventilation openings provided with vermin proof screens.

11 Switchpanels and control boards shall be the products of specialist manufacturers of this class of equipment, as approved by the Engineer, and shall be purpose made to contain all switchgear, controls, instruments and indicating equipment, and shall be complete with all internal wiring, all conforming with the following requirements.

12 Switchpanel and control board casings shall be fabricated from 2,0mm thick mild steel suitably stiffened with mild steel sections and fitted with removable, hinged doors, with flush-mounted locks each provided with triplicate keys, as well as removable panels secured with chromium plated dome nuts.

13 Wall mounting panels shall be of the surface type with removable inner mounting chassis.

14 Floor standing switchpanels and control centres shall be mounted on channel section mild steel bases.

15 Door widths shall not exceed 900mm for all switchpanels and all doors, removable covers, door pillars, mullions, etc., shall be dust resistant and provided with oil resistant, closed-cell composition, synthetic rubber or similar gaskets. Gasketed surfaces shall be so constructed that gasketing material is retained by metal channels and does not depend entirely on an adhesive holding the gasket on a flat metal surface.

16 All fixing screws shall enter holes tapped into an adequate thickness of metal or nuts welded to the back surface of the metal plates. Self-tapping screws will not be accepted.

17 Switchpanels shall be so designed that no circuit breaker toggles shall protrude through the doors. All switches, the main circuit breakers, on\off handles, instruments and indicating equipment, reset buttons and pilot lamps only shall however, be fully exposed and operable, as relevant, without the need to open the doors to the switchpanels, this equipment being flush mounted on the door of the switchpanel or on a fixed panel section on one side or on top of the switchpanel.

18 Adequate barriers shall be provided in the switchpanels to segregate load circuit compartments from the busbar chamber, in such a way that transmission of flame from one compartment to another is minimized.

19 The electrical equipment within the panels shall be mounted on steel chassis. Such chassis shall also be used for the mounting of the relevant busbars.

20 Finish of the panels shall be in enamel. Orange on the outside and White inside. oards shall be given three coats of paint after an initial coating of zinc-rich primer to give a high-class gloss finish. Colour samples of the Orange enamel paint shall be approved by the Engineer prior to the switchpanels being painted. All switchpanels and control boards shall be fitted with earthing straps, in accordance with the standard wiring regulations.

21 Busbars shall be provided in hard drawn annealed copper loaded to not more than 1,55 Amps per mm^2 of copper on a ± 50 °C rise and shall be enclosed in a top horizontal and accessible compartment with steel casing separating the busbars from other equipment. Busbars shall be mounted on porcelain or epoxy resin type busbar insulators mechanically braced to withstand 40 KA through fault current. The clearance between busbars shall not be less than 40mm between phases and 25mm to earth, and they shall be secured by bolts having a diameter of not less than the

thickness of the busbars with a minimum diameter of 8mm. Machined bolts and nuts with washers and spring washers shall be used and busbar supports shall have a maximum pitch of 900mm. Connections shall be made by means of copper, preferably double indent, compression lugs. All busbar joints shall be silver or tin plated and connected with high tensile steel cadmium plated bolts and lock washers. Busbars shall be taped after all connections are made. Busbar droppers to circuit breakers shall be of minimum section 10 mm² single copper conductor.

22 Neutral bars are to be not less than half the cross-sectional area of the phase busbars, but not less than 25mm x 6mm, and are to be mounted on porcelain or epoxy resin type insulators, where heaters or other phase to neutral loads are used.

23 Where neutral bars are purely on the control side, 15mm square brass bars with 2 tapped holes per way may be used, mounted on bakelite or equal insulators.

24 Earthing straps of not less than 25mm x 6mm copper shall run the full length of the complete floor standing panels, either at the top or bottom of the panels where it must be securely bolted to the switchpanel framework to ensure good continuity.

25 Wall mounted switchpanel shall be provided with an earthing brass bolt of not less than 10mm diameter, securely fixed to the panel chassis.

26 All wiring within the panels shall be neatly grouped in horizontal and vertically run approved fire resistant P.V.C. trunking with clip-on removable covers. All wiring shall also be colour-coded in the colours red, white and blue for the relevant phases and black for neutral, the busbars being similarly marked.

27 Power wiring shall be of 2,5 mm² minimum section P.V.C. covered stranded wire rated for 600 volts.

28 Control wiring from the secondary side of control transformers shall be minimum 1,5mm P.V.C. covered, stranded, 250 volt grade wire with bared ends soldered. All switchpanels shall be carefully designed and sized to ensure ample space for wiring and making-off incoming cables.

29 Where required (due to fault level considerations) Current Limiting Circuit Breakers shall be used to reduce fault current levels to less than 5kA r.m.s., alternatively 7,5 kA "let-through-current". The circuit breakers to be used shall be the manually operated trip-free type with adjustable magnetic\thermal trips in each phase.

30 All fuses shall be of the HRC type with minimum rupturing capacity to suit the system fault levels at 400 volts. Spare fuses of 25% of the total quantity with a minimum of three of each size and type, including control circuit fuses shall be provided.

31 Isolators shall be of the 'on load' type and of ample rating for the maximum load applicable. Live side terminals on all isolators must be shrouded or otherwise insulated against inadvertent contact.

32 Isolators installed within the switchpanels shall be housed in separate enclosures, the door of which shall be interlocked with the switch operator to prevent the door from being opened unless the switch is in the open position and prevent closing of the disconnect switch while the door is open unless a manual by-pass is actuated, also to prevent closing of the disconnect switch until the door hardware is fully engaged. The stem operating the isolator shall not be less than 12mm in diameter and shall not protrude more than 100mm. Provision shall be made for padlocking the

disconnect switch in the open position only with up to three 10mm shackle padlocks regardless of whether the door is open or closed.

33 Air break circuit breakers shall be of the double break type, and shall have a continuous rating not less than the total full load rating of the equipment. They shall have a fault capacity suitable for the design level of the system. They shall have adjustable overloads, covering the operating range of the equipment served, which shall be series tripping up to 800 Amp and C.T. operated above this value.

34 Moulded case air circuit breakers shall be rated to comply with a minimum fault level of 6kA and a current rating to suit the load and shall be fitted with thermal overloads and instantaneous magnetic over-current release.

35 Current transformers shall be air insulated and shall have an accuracy within 2% of the 0-100% scale output. One leg of secondary winding shall be solidly earthed.

36 Magnetic contactors shall not be smaller than N.E.M.A. size 1 or equivalent, with encapsulated operating coils rated at 220 Volt, 50Hz. Each starter is to be furnished with one spare N.O. (Normally Open) and one N.C. (Normally Closed) auxiliary contacts rated at 5 amperes. Each starter shall also have provisions for adding two additional sets of auxiliary contact, either normally open or normally closed. Contacts and coils shall be replaceable without removing the entire contactor from the cubicle.

37 Motor Starters shall comply with BS 775 and N.E.M.A. specifications and shall have thermal overload relays which shall be of the bimetallic ambient temperature compensated, manual reset type. Overload relays shall be resettable at any time after tripping without rendering the relays inoperative. All terminals shall be shrouded and the contact mechanism shall be trip-free so that the snap action contacts cannot be held closed against continued overload. The ultimate trip current of overload devices shall be nominal 115% of the motor full load current.

38 With special hard starting, e.g. centrifugal fans, it may be necessary to increase the nominal value but in no case shall the overload ultimate trip current exceed 130% of the motor full load current.

39 Control relays shall be either of the heavy duty industrial type, 600 volt with minimum 10 ampere replaceable contacts and shall be equipped with 110 volt, 50 Hz holding coils for continuous operation within a voltage range of 100 to 120 volts. Holding coils shall be replaceable without removing the entire relay from the cubicle or;

40 Alternatively the control relays may be of the plug-in type, hermetically sealed in plastic containers.

41 Phase failure SEQUENCE PROTECTION relays shall be arranged to shunt trip the incoming breakers so that on failure or phase reversing the plants will stop.

42 Timers shall be of the totally electronic unit type similar or equal to SIEMENS.

43 Sequence controllers to start plant with minimum of 20 seconds time delay between each start-up of motors of 3kW and over shall be provided to avoid heavy current inrush on plant start-up. Sequence controllers shall be totally electronic unit type and shall automatically recycle to zero position after power interruption and on normal plant shutdown.

44 Pilot lights shall be of the LED multi-lamp, push to test type, equal to SIEMENS with round 'plexiglass' face engraved to indicate the function. The colours of the face plates shall be as noted below:-

- Indication (Amber)
- Operation (Green)
- Failure or Alarm (Red)

45 Pilot lights shall be grouped in the sequence of operation of the plant components with amber coloured lamps generally above green lamps and the red 'failure or alarm' lamps below the respective green 'operation' lamps.

46 Reset Pushbuttons shall be similar in appearance and size to the pilot lights, equal to SIEMENS and shall be mounted adjacent to the Red Failure or Alarm pilot lamps on the switch-panels.

47 At least 1-off Voltmeter and 1-off ammeters shall be fitted to panels with power circuits bigger than 5kW.

48 Also, when indicated on the Wiring Diagrams only, the main incoming switch of the switchpanel shall be fitted with a kWh-meter, three Ammeters and one Volmeter with selector switch.

49 Kilowatt-hour meters shall be fitted as specified on the Drawings. The meters shall have 6 digits and manual reset knob. Above 100 Amp the kWh-meter shall be fitted with current transformers.

50 Ammeters shall be fitted in the power circuits of all motors of 5kW and over and where specified or shown on the Drawings. Ammeters over 50 Amps shall be operated by current transformers of the ring type. Ammeters shall have an accuracy of 2% of the scale range or better. For non-inductive loads the scale of ammeters shall not exceed the maximum current drawn by more than 40%. Motor ammeters shall be suitable for the starting current of the motor, and shall have an extended scale in the region of the operating current.

51 Volt meters shall be of the moving iron or moving coil type.

52 All indicating instruments shall be of the flush mounted square face pattern with 96mm dials.

53 Each control circuit shall be protected with a single pole circuit breaker. Controls shall be suitable for 220 volt operation.

54 Terminal boards or blocks shall be mounted in each switchpanel for all external connections and shall be so located that they are readily accessible from the front of the switchpanel, and not in the wiring gutter leaving it completely free for power and control wiring. If terminal blocks are of the 'split' disconnect type the female part shall be secured to the removable unit cubicle and the male part free and be of a closepin type. The disconnect type terminal blocks shall be held together with screws or clamps. Terminal strips shall be properly labelled and panel field wiring shall be marked accordingly by the means of numbered ferrules. Not more than one incoming and one outgoing wire shall be fixed to any one terminal.

55 Labels showing the unit designations shall be provided adjacent to each of the terminals.

56 The switchpanels shall be fully labelled with engraved black ivorine labels having 6mm high white lettering. The labels shall be bolted to switchpanel cover or chassis plates to identify all switchgear, relays, instruments and controls, etc., on the face of or inside the switchpanels.

57 Equipment operating above 250 volts shall be fitted also with a red danger label.

58 Embossed Tape or Labels fixed with adhesive will not be accepted.

59 The Sub-contractor shall be responsible for marking all switchgear and other equipment on the Wiring Diagrams with the wording of the labels to be used.

60 All cable terminals shall be clearly identified by permanent labels.

61 Every wire inside and outside the switchboard shall be fitted with ferrules and labelled with identical numbers at both ends.

62 All terminal numbers and wire identification numbers shall correspond with identical numbers which must be shown on the wiring and control Diagrams.

63 Work tests may be witnessed at the discretion of the Engineer, who shall be given one week's prior notice in writing of the date on which they will take place. Three copies of Wiring Diagrams and ladder type schematic Diagrams complete with terminal numbers shall be sent to the Engineers at least fourteen days before testing can be commenced.

64 Testing shall be carried out on all completed equipment, including:

65 High voltage insulation and insulation resistance tests to earth and between phases.

66 Satisfactory operation of relays shall be proved.

67 Closing and opening operation of all starters and contactors shall be satisfactorily demonstrated.

68 All mechanical interlocks shall be satisfactorily demonstrated.

69 Satisfactory operation of current and voltage instruments.

70 Operation of all control circuits shall be proved by simulating operation of switching devices in the external circuit.

71 In addition, all components parts shall comply with the type specified in the S.A.B.S. or B.S. Standards.

72 The pre-delivery tests is not a final acceptance test, and does not absolve the Sub-contractor from his responsibility for the switchpanels.

73 All protective devices throughout shall be correctly set by the Sub-contractor to the approval of the Engineer. Before any circuit is energised, the data for correct setting to be established.

74 The Sub-contractor shall be responsible for the complete electrical installation. Selection of equipment of appropriate rating and capacity, including the rupture of fuses and circuit breakers, covered under this Sub-contract.

75 Provide for each item of equipment located out of sight of the electrical switchpanel serving same, a remote-on-load isolator housed in a dustproof case. Where isolators

are located in positions exposed to weather, they shall be waterproof type fitted with suitable watertight cable entry glands.

76 Indoor Electrical Panels shall be IP45 rated and All Outdoor Panels Shall be double door, IP 54 complete with rain/weather shield.

4.0 MANUFACTURE AND INSTALLATION

4.1. AIR FILTERS

1 The filters shall be manufactured by **AAF, TROX** or approved equal.

2 Pleated panel filters:

3 Air filters shall be installed before the coils in the packaged air conditioning units and the air handling units and heat recovery wheels and shall be minimum 50mm thick high performance washable pleated panel filters. The filters shall comply to Eurovent 4/9 category EU2 (or EN779 /EN 1882 category G2).

4 The filter media shall be a random layed, non-woven, synthetic, polyester fibre that has been saturation bonded.

5 The media shall be pleated between two layers of 25mm x 25mm 22 gge coated wire mesh. Both layers of wire must conform to the profile of the pleats. The pleat shall be evenly spaced, must not touch one another and shall be open both back & front to allow maximum dust holding and ease of cleaning.

6 The filter frame shall not be thinner than 26gge (0,5mm) galvanised mild steel.

7 The filter cartridge shall be sealed into the enclosing frame by means of a mediapack and frame.

8 Long life bag air filters installed in independent air filter banks in Plantrooms or before the coils in packaged air conditioning units and air handling units and heat wheels, where indicated on the Drawings, shall be extended surface air filters with filter media having an arrestance of 90% (ASHRAE) The filters shall comply to Eurovent 4/9 category EU4 (or EN779 /EN 1882 category G4). Bag filters shall be of a approved disposable type. The filter will be a high performance filter and consist of high density glass microfibre media with a chemically bonded backing and individual pockets with a galvanised steel frame with corrosion free properties.

9 Each filter cell shall be suitable for the manufacturer's recommended airflow of 0,833 m^3/s at an initial resistance of 20Pa. Manometers to be used in conjunction with these filters shall be set for a final resistance of 150 Pa.

10 Fresh air filters shall be of the same make, type and size as the return air filters fitted in the units and shall be fitted into the holding frames installed on the rear of the outside air intake weather louvre so as to be easily removable from inside the plant room area or building.

11 Air filters shall be fitted into holding frames (easy clip in-out) that shall be so designed to allow a negligible quantity of air to bypass the filters.

12 All filter banks shall be mounted in easily accessible positions and shall be reachable with a normal 1.8m long ladder.

4.2. CHILLED WATER & REFRIGERANT PIPEWORK INSULATION

INSULATION FOR CHILLED WATER PIPELINES TO PREVENT CONDENSATION AND TO CONTROL HEAT GAIN. REFER TO THERMAL INSULATION CHART.

1 Chilled water piping shall be insulated, using closed cell elastometric foam insulation.

2 The insulation shall be **THERMOBREAK or ARMAFLEX or VIDOFLEX**

3 The insulation should conform to the following technical data:

- i) Thermal conductivity at 20 ° C - 0.034 – 0.039 W/m°k, Meant T of 0 ° C (to standard DIN 52612 / 52613, BS 874: PARTS 2)
- ii) Water vapour diffusion resistance factor better than 5000-7000 (DIN 52615 AND BS 4370/2).
- iii) Water vapour permeability better than 0,09 ugm/Nh (DIN 52615 AND BS 4370/2)
- iv) Closed cell content > 90%
- v) GGG

4 The insulation should have a minimum fire rating:

- i) BS 476 Part 7 1987 (surface spread of flame) - class 1
- ii) BS 476 Part 6 1989 (Fire propagation) - class 0.
- iii) Toxicity - SNCF (France) Rating - Class F2.
- iv) Corrosion Rating - As per DIN 1988/7
- v) Density - 45 - 65 kg/m3
- vi) Noise Reduction - Up to - 32db (A) at 500Hz.
- vii) Applications (Detailed calculations to be submitted to the Engineer to ensure that no condensation or excess heat gain occurs for any lengths of pipework in unconditioned spaces. The following are basic guides:
- viii) Pipe diameter up to 5" - 25mm
- ix) Pipe diameter of 6" to 10" - 25mm
- x) Pipe diameter of 12" to 20" - 25mm
- xi) Pipe diameter above 20" - 25mm

5 In Plantrooms or UV exposed areas or as indicated on the drawings the piping will have a 0,5mm galvanised cladding for piping up to 65mm diameter and 0,7mm thickness for piping greater than 65mm diameter..

6 The jacketing will be secured by Mechanical clips or Metal Clamps. To be tightened by means of a crimping tool or similar. Silicon sealer to be used around all joints. Securing arrangement to be submitted to Engineer for approval. The jacketing will be secured with 10mm strapping and crimp type seals and silicon sealer around all joints

7 Where pipe supports are located hardwood or rubber blocks are to be incorporated which are to be suitably vapour sealed in conjunction with the associated insulation.

8 Manufacturer to submit the following certificates:

i) Third party certification for Class 0 testing.

ii) FM certification for manufacturing.

INSULATION FOR CONDENSATE WATER PIPLINES TO PREVENT CONDENSATION

1) NO PVC on drains.

2) Copper on FCU drains

3) Galvanised Steel on AHU drains.

4) Insulation on condensate piping as per chilled water piping INSULATION CHART.

NOTE:
ALSO REFER
"THERMALLY INSULATED UNDERGROUND PIPELINES"

4.3 COOLING COILS (CHILLED WATER)

1 All coils shall be suitable protected during shipment and installation so that the fins and casing flanges are not damaged. If fins are damaged they may be combed so as to restore them to the original shape and/or spacing. If however, in the opinion of the Engineer the coils have loose or damaged fins at the time of final inspection they will be rejected and shall be replaced with new coils.

2 Coils shall have aluminium fins mechanically bonded to seamless copper tubes. For sprayed coils fins shall be of copper. The fins shall be spaced not closer than 12 per 25mm. The pressure parts of coils shall be constructed and tested to a pressure of not less than 1 700 kPa. Water coiling coils shall be of the serpentine type and headers shall be welded steel, cast iron, brass or copper. Headers shall be provided with vent and drain connections.

3 Each coil section shall be securely mounted in a die formed zinc coated sheet steel casing with a minimum thickness of 1,60mm. Casing to be arranged for bolting to other sections, ductwork, unit casings, etc. Coil sections shall be supported on angle frame or other strong rigid construction. Supporting frame shall be hot dip galvanised. The coils shall be rigidly braced to ensure that there is no bending or flexing.

4 Drain pans shall be provided with drain connections on both sides. The drain pan shall run the full width of the coil and shall be treated in an approved manner to prevent corrosion. Condensate drain piping shall be not less than 20NB.

5 Face velocities shall not exceed 2,75 m/s.

4.4. CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS

1 The copper tubes and aluminium (or copper) fins of the condensing unit shall be treated with an anti-corrosion chemical treatment. The treatment shall conform to the 'BLUCHEM' method of application using BLUCHEM anti-corrosion chemical coating or treatment of a similar quality and applied only by a certified applicator using proper high pressure spraying equipment and following the certified treatment procedure.

2 The protective coating must achieve a total coverage and shall not block the clear spaces between fins or any fin perforations. The coating must have excellent adhesion while still being flexible so that the contraction and expansion of the base metal will not cause peeling or flaking. The protective coating must be UV resistant, dirt repellent, repairable and maintainable on site and must not have any adverse effect on heat conduction.

3 The Bluchem coil treatment process shall provide a minimum warrantee period of three (3) years against coil corrosion for untreated (virgin) and factory pre-treated coils.

CERTIFIED METHOD OF TREATMENT

4 Ensure condenser unit is properly enclosed to protect surroundings against possible chemical overspray and to ensure dirt/dust does not contaminate the condenser coil during the treatment process.

5 De-crate equipment and remove protective panels and wire mesh guards.

6 Remove discharge fan assembly (if necessary/if possible).

7 Apply high quality chemical cleaner to the condenser coil and allow 10 minutes reaction time.

8 Clean coil with high-pressure water.

9 Comb all damaged or irregular condenser fins.

10 Lightly brush condenser fins with soft brush to verify all traces of corrosion have been removed; re-clean if necessary.

11 Dry with high-pressure air.

12 Apply 2 coats of Bluchem coil treatment to both sides of the condenser coil following the prescribed Bluchem method and using only certified high-pressure spraying equipment.

13 Apply 4 coats of Bluchem coil treatment to both sides of the condenser coil following the prescribed Bluchem method and using only certified high-pressure spraying equipment.

14 Allow 2 hour curing period.

15 Remount the protective panels and re-crate equipment.

APPEARANCE

16 The coated coil must have a blue finish and the chemical coating penetration has to be 100%, to be established by the aforementioned proven method of treatment.

THICKNESS LEVEL OF PROTECTIVE COATING

17 The thickness level should meet 20 µm plus or minus 20%.

4.5. DAMPERS

1 Dampers shall be provided where shown on the Drawings for shut-off, bypass or volume control purposes or where required to comply with local fire codes.

2 Volume control dampers shall consist of multiple blades acting in opposed blade manner, the blades being robustly linked together to operate in complete unison. Individual blades shall be hooked-edge construction, so bent for rigidity or extruded into rigid aerofoil sections. The blades shall have steel trunnions mounted in bronze or PVC/Plastic sleeve bearings or ball bearings. Permanently set dampers shall be provided with suitable devices to facilitate locking them in position with 'Open' and 'Shut' position indicated.

3 Motorised dampers shall include suitable fastenings and supports for motor actuators.

4 Damper hardware shall be the product of an accredited manufacturer of such items. Damper sections shall be housed in flanged steel metal casings of a minimum 1,25mm thick galvanised steel. Damper blades shall not exceed 200mm in width and 1000mm in length. Dampers over 1000mm in length shall be sectionalised into separate cells each with its own shaft and bearings to ensure that the blade length of each section does not exceed 1000mm.

5 Where manual adjustable dampers are required they shall be supplied with a hand locking quadrant with a position indicator.

6 Where motorised dampers are indicated on the drawings, actuators are to be **BELIMO** or equal and approved. The dampers main blade adjustment spindle/shaft is to be extended so the actuator’s drive mechanism can adequately engage this shaft.

7 Should this actuator be installed on a fire damper installation, the actuator is to be suitably rated and fail to a safe position under fault or loss of power conditions.

8 Fire dampers , Smoke Dampers, and Fire-Smoke dampers combo shall be UL listed and be **TROX, ELECTROVENT or equal and approved** and manufactured to a recognised fire code with a two-hour fire rating. Damper casings shall have flanged ends and damper blades shall not exceed 300mm in width. The fire dampers shall comply in all respects with the requirements of the local municipal fire authorities in the area where they are to be installed.

9 Damper blades shall be closed by the operation of approved fusible links located where they would be immediately affected by an abnormal rise in temperature of the air stream. When called for on the Drawings, solenoid actuators that shall be provided by the damper manufacturer shall activate the blades. When closed the blades shall be held by a catch arrangement so as to provide a positive seal against the air stream.

10 Duct mounted air volume control dampers and fire dampers installed in ducts shall be provided with a minimum 300 x 300mm inspection opening so that the dampers may

be checked, maintained and reset when required. These inspection openings shall be covered with suitably sealed access panels.

4.6. DIFFUSERS, GRILLES AND LOUVRES

1 Air distribution shall be effected by means of ceiling diffusers or grilles of the sizes, types and having the discharge patterns as indicated on the Drawings.

2 Ceiling Diffusers and grilles shall be fixed to spigots extending not less than 100mm from the ducting, unless otherwise indicated on the Drawings, and shall be securely fixed so that no screws or other fixing devices are visible.

3 Supply air diffusers shall be of steel construction and shall consist of an inner core which shall be easily removable from the outer section to facilitate access to the volume control damper located behind the diffuser. The inner core shall consist of concentric rectangular collars and the outer section shall consist of a single rectangular or bevel collar provided with a concealed spigot for attaching the diffuser to the supply ductwork.

4 The rear backing including the disc of all supply air diffusers for coastal projects, shall be lagged with minimum 3mm thick life care - fire and heat resistant foam.

5 Supply air diffusers shall be **TROX, RICKARD (CCD or VCD) , TITUS, EUROPAIR, KRANTZ & NAI** as indicated on the drawings complete with dampers, and shall be finished in an epoxy powder coating in a colour to suit Architects requirements. Alternatively aluminium diffuser casings will be acceptable.

6 Supply air grilles shall be of the double deflection type consisting of two rows of individually adjustable aerofoil section vanes, the front vanes being horizontal and the rear vanes vertical. The vanes shall be housed in a surrounding fixing flange with neat mitred joints at the corners. The entire grille assembly shall be of extruded aluminium construction and shall be finished in plain anodised aluminium unless otherwise noted on the Drawings.

7 Supply air grilles shall be **TROX, RICKARD (CCD or VCD) , TITUS, EUROPAIR, KRANTZ & NAI** complete with factory fitted opposed blade dampers.

8 The multivane opposed blade dampers provided with supply air diffusers and grilles shall be finished in matt black lacquer. The dampers shall be attached to the rear of the grilles and fitted into the spigot connections or the diffusers and shall be adjustable, by means of a key or a lever, from the front of the installed diffusers and grilles.

9 Return air grilles shall consist of aluminium grid core housed in an extruded aluminium fixing flange with neat mitred corners and finished in plain anodised aluminium unless other noted on the Drawings.

10 Return air grilles shall be equal to **TROX, RICKARD (CCD or VCD) , TITUS, EUROPAIR, KRANTZ & NAI** grid core.

11 Door grilles shall be of extruded aluminium construction to **TROX, RICKARD (CCD or VCD) , TITUS, KRANTZ & NAI** suitable for fitting into doors of varying thickness and shall be finished in a colour to suit Architects requirements. Door grilles shall be fixed to doors by means of countersunk screws with a colour to match the door grille.

12 Fresh air louvres if specified on drawings, outside air intake sand traps louvres shall have a double deflection inlet route so as to separate the sand particles from the incoming air. A vermin proof screen on the rear side shall be included.

13 The Louvre shall have an efficiency of not less than 90% at a face velocity of 1m/sec, & an efficiency of 70% at a face velocity of 2 m/sec.

14 Pressure drop at 2 m/sec shall not exceed 120 pascals.

15 The louvre shall be supplied with a powder coated finish with the colour to the Architects approval and installed so sand or water is easily drained to the outside.

16 Rubber gaskets shall be glued to the rear of the fixing flanges of all diffusers, grilles and louvres to ensure airtight seals and prevent smudging.

17 Mechanical / HVAC Contractor shall be responsible for the reticulation and installation of the required electrical power wiring from the associated HVAC electrical control panel / Motor control Panel for the Electric Diffuser Re-heater Batteries, complete with all required thermal heat safety thermostats and positive airflow confirmation interlocks.

4.7. DRAINS

1 Provide all necessary drain piping laid to suitable falls from every item requiring such drainage. Such drains shall be run to the adjacent relevant drain points shown on the Drawings.

2 Drainage pipework shall be adequately sized and carried out generally in medium grade galvanised piping, all connections to equipment being effected with conicalfaced unions or flanged.

3 All drains from cooling coil pans for condensate disposal shall be fitted with proprietary U-traps to prevent backflow or non-drainage due to negative air pressures.

4 Drainage pipework of longer than 4,5m run shall be provided with cleaning eyes on all bends to facilitate maintenance.

4.8. DUCTWORK

1 Ductwork shall be carried out in accordance with the details shown on the Drawings and shall be fabricated from prime quality galvanised sheet steel. All duct sizes indicated on the drawings are metal sizes and include the necessary allowances for any internal insulation which may be specified.

2 Ductwork shall be fabricated and installed in accordance with the following specification which shall be read in conjunction with the standards set by the Sheet Metal and Air Conditioning Contractors National Association of America (SMACNA) which shall be adhered to in detail except only as hereinafter specified.

4 Rectangular ductwork sheet steel thickness and cross breaking length shall be as follows:-

Duct Size	Duct Joint	Sheet Steel	Sheet Steel	Cross Breaking	Type of
long side		thickness	gauge	length	Intermediate
[mm]		[mm]		[mm]	Stiffener
Up to 750	Slip & Drive	0,6	24	2400	None
Up to 760	Mez	0,6	24	2400	None
751 to 1250	Mez	0,8	22	2400	None
1250 to 2400	Mez	1,0	20	1200	Tie-Rods
Above 2400	Mez	1,2	18	1200	Tie-Rods &Flat V Top Hat

4 Longitudinal seams shall be Pittsburgh lock on all duct sizes. Cross joints on concealed ductwork having a semi-perimeter not exceeding 1150mm shall be as follows:-

Duct Size	Long Side	Short Side
[long side mm]		
Up to 450	'S' slip	Drive Slip
460 to 750	25mm Bar Slip	Drive Slip

5 Cross joints on concealed ductwork having a semi-perimeter in excess of 1150mm shall be of Mez or equal flange type, installed in accordance with the manufacturer's recommendations. As an alternative to the Mez or equal flange joints, 40mm x 3mm angle flange joints may be used.

6 Cross joints on all exposed ductwork shall be of Mez or equal flange type.

7 Panel stiffening shall either be cross breaking, beading or pleating of longest side on all ducting.

8 Ductwork supports shall be of rod and angle type, sheet metal straps not being permitted. The size and spacing of these supports shall be as follows:-

Duct Size	Angles	Rods	Spacing
long side mm	mm	dia mm	Max - mm
Up to 750	40 x 3	6	3000
751 to 1250	40 x 3	8	3000
1251 to 2400	40 x 6	10	2400
Above 2400	50 x 6	12	2400

9 Rectangular ductwork shall be regarded as low velocity low-pressure ductwork suitable for pressures up to 500 Pa and velocities up to 10 m/s. It shall accordingly be fabricated and installed to comply with the above requirements and the "Low Velocity Duct Construction Standards" manual published by SMACNA.

10 All cross joints in ductwork shall be sealed with a liberal coating of 3M or equal Duct Sealer. Longitudinal joints/seams exposed to weather shall be made waterproof.

11 All duct connections to vibrating equipment shall consist of a flanged joint, followed by a flexible connector consisting of a neoprene covered fibreglass cloth fixed on either side of the joint in a double lock seam to form an airtight flexible joint with a minimum of 50mm separation between metal edges. Ducting at flexible joints shall be so supported that the ductwork is held square with the adjoining ducting and no stress is imposed upon the flexible joint. Copper earthing straps shall be fitted over all flexible duct connections and be carried out in accordance with the standard wiring regulations.

12 Flexible ducts shall be insulated & to the Engineers approval, comprising glass fibre fabric, P.V.C. coated with spirally wound metal inserts. Where flexible ducts connect to normal sheet metal ductwork or other equipment, a liberal coating of 3M or equal Duct Sealer shall be used, the joint then sealed with 75mm wide duct tape and finished with an approved clamp or metal strap (like ***SimClip or equal and approved***) to ensure an airtight joint. The Simclip or equal and approved device to be an all purpose re-usable adjustable clamp and strapping device, to be user friendly, quick and easily assembled to form a strong permanent rust resistant clamp fastener. The clamp and split-pin combination, which comprises of a galvanised sheet metal clamp which houses a steel split-pin must be electroplated for rust prevention. The Galvanised sheet metal strip must be at least 10 mm wide and 0.5 mm thick.

13 Circular flexible ducting connected to supply air diffusers shall not exceed 1,5 metres in length.

14 All supply air ducting shall be pressure tested with a maximum permissible leakage of 5% at a test pressure of twice the working pressure.

15 The maximum permissible leakage rate for return and ventilation air systems shall not exceed 5%.

16 Kitchen canopy and fume extract air ducting systems shall be made 100% air & liquid tight and is to be constructed of welded and flanged 1mm black mild steel if not otherwise specified. Refer to latest **SANS 1850,** Section 4 (flanges to be peened, etc.)

17 All insulated ducting in storage or in position shall be adequately protected at all times.

18 All ducting joints exposed to weather shall be waterproof and corrosion free.

4.9. DUCTWORK INSULATION

1 Ductwork shall be insulated according to the requirements noted on the Drawings and in accordance with the INSULATION CHART ATTACHED and the following specifications

2 The exposed supply and return air ducting shall be externally insulated with: **THERMOBREAK or ARMAFLEX or VIDOFLEX with reinforced foilface finish**

3 For concealed supply and return ducting shall be externally insulated with: **THERMOBREAK or ARMAFLEX or VIDOFLEX without foilface finish**

4 Specifications:

i) Thermobreak - Electron Beam (Physically crosslinked, closed cell Polyolefin foam with factory applied heavy duty re-enforced aluminium foil with triple direction scrim.

ii) Armaflex - Closed cell elastomeric rubber insulation. When used on exposed ducting this has to be with Factory applied re-inforced aluminium foil with triple direction scrim.

iii) Vidoflex - Closed cell elastomeric rubber insulation. When used on exposed ducting this has to be with Factory applied re-inforced aluminium foil with triple direction scrim.

iv) Factory applied acrylic adhesive backing.

v) Density: Min 25kg/m3

vi) Thermal conductivity: Maximum 0.034 – 0.039 W/mK mean T of 0 ° C (to standard DIN 52612 /52613, BS 874: PARTS 2)

vii) Moisture Absorption: Non hygroscopic., max 1% (vol).

viii) Water vapour permeability: Better than 0.8gm/m2/24 hrs (90% RH 38 ° C)

ix) Minimum service temperature: -80 ° C

x) Maximum mean duct service temperature: 90 ° C

xi) Maximum service temperature: 100 ° C

xii) Water vapour diffusion resistance factor better than 5000 - 7000 (DIN 52615 AND BS 4370/2)

xiii) Water vapour permeability better than 0,09 ugm/Nh (DIN 52615 AND BS 4370/2)

xiv) Closed cell content > 90%

5 The minimum fire rating properties of the insulation material when tested to BS 476 parts 6 is Class 0 and to BS 476 parts 7 Class 1.

6 Installation :

i) The insulation must be installed to manufacturer's instructions and recommendations.

ii) All joints should be butted firmly against each other, seal joints with 75mm reinforced aluminium foil tape.

iii) No gluing of joints is required.

iv) Insulate all ducts separately, flanges should be insulated with 120mm wide strip of insulation material, ensuring joints are sealed with 75mm reinforced aluminium foil tape.

v) No additional vapour barriers or coatings are required if armaflex or thermobreak used.

vi) All supporting hangers should be lined with the same insulation material to avoid excess compression of insulation. (Refer manufacturer's instructions)

vii) Ensure no air pockets during the installation of the insulation to the duct.

viii) Ensure any surface cuts are covered with 75mm aluminium foil tape to ensure a continuous vapour barrier.

ix) If the insulation is damaged on site by other contractors or any other means, it is the responsibility of the HVAC contractor to fix the insulation so that the engineer accepts the installation, and coordinate with the main contractor for any financial issues.

7 Detailed calculations are to be done for any duct runs in non air- conditioned spaces to ensure condensation and excessive heat gain is minimised, these details are to be forwarded to the Engineer to comment. Insulation must always be increased to minimise condensation and excess heat gain.

8 For exposed ductwork in direct sunlight the ductwork insulation is to be increased to ensure a maximum of 1 ° C supply and return air temperature rises respectively. A light coloured or reflective layer is to be installed with this type of installation to Engineer's approval.

9 Manufacturer to submit the following certificates:

- Third party certification for Class 0 testing.

- FM certification for manufacturing.

10 Ducting to be 0.5mm galvanised sheets clad in Plantrooms or as noted on the drawings or where exposed to UV.

4.10. EQUIPMENT BASES

1 Provide, as called for in the Detailed Technical Specification or as indicated on the Drawings, equipment bases of the applicable type as specified below:

2 Inertia bases shall comprise a reinforced concrete pad of mass one and half times that of the equipment to be mounted upon it. A welded mild steel tray suitably reinforced and of sufficient depth to contain the required weight of concrete, shall be provided by the Sub-contractor. Welded into such trays shall be a suitable template complete with the necessary ragbolts suitable for rigidly affixing the equipment to the base, once concrete has been cast in. The Principal Contractor will pour concrete into the tray and smooth plaster it with coloured granolithic finish. The steel tray is to be positioned on an 80mm high smooth plastered "housekeeping" plinth, such plinth provided by the Principal Contractor and 150mm larger than the steel tray all round.

The inertia base shall be separated from the plinth by suitable vibration isolators, as later detailed, proper provisions in the design and construction of the steel tray being made for the attachment of the necessary vibration isolating mountings.

3 Floating steel bases shall be shop-fabricated from mild steel channel sections of sufficient strength and rigidity using welded joints. Such bases shall, unless otherwise called for elsewhere or noted on Drawings, be of rectangular shape and at least 80mm larger in all plan dimensions than the equipment to be mounted onto it. The construction of the base shall be such that proper provisions are incorporated for attaching laterally or fitting beneath it, vibration isolators of the type that each application may require. The principal Contractor will provide a level "housekeeping" plinth on which to mount the aforementioned steel base, the plinth to be 100mm minimum larger than the base all round.

4 Static plinths, 80mm minimum high, shall be provided by the Principal Contractor for mounting non-vibrating equipment upon them, the plinths to be rectangular in shape unless otherwise shown on the Drawings and 100mm larger all around than the equipment to be mounted upon them.

5 The Sub-contractor shall provide and position, where required, a channel iron frame, with mitred welded corner joints, and sheet metal bottom tray for the Principal Contractor to fill with concrete. The finish of the plinths shall be tinted granolithic.

6 Anti-vibration mountings shall be utilised in conjunction with the aforementioned bases, as relevant and as indicated on the Drawings for the following listed items of equipment,

7 All anti-vibration mountings shall be installed in full accordance with their manufacturer's application instructions.

8 All equipment bases and anti-vibration mountings shall be corrosion free.

Equipment	**Minimum Static Deflection**	**Type of Mounting**
Air Conditioning units		Neoprene
Air Handling units and condensing units on concrete floors or bases.		Vibration Pads
Cooling Towers over non-occupied areas		Neoprene, Vibration Pads
over occupied areas	To suit fan speed	Helical Spring with levelling adjustment
Centrifugal Pumps over non-occupied areas		Neoprene, Vibration Pads
over occupied areas	19mm	Helical with levelling Spring adjustment
Axial Flow Fans	6mm	Neoprene in sheer and Compression.

9 Full details of all floating steel bases and all anti-vibration mountings selections shall be approved by the Engineer prior to the mountings being ordered and the bases fabricated.

10 Where applicable, the Sub-contractor shall exercise particular care to prevent damage to the roof slab when hoisting, positioning and connecting the air conditioning units and shall note that he will be held responsible for repairs caused as a result of this installation.

11 All equipment and particularly that which is mounted on the roof shall operate without objectionable noise or vibration being transmitted to the full satisfaction of the Engineer.

12 All cut joints and holes drilled within ducting, equipment casings, supports, stands, platforms, suspension brackets and supporting cable trays shall be fully protected against corrosion.

4.11. EQUIPMENT SUPPORTS

1 Where equipment supports, stands, platforms and suspension brackets are indicated, specified or necessary for ductwork, pipework, etc., the Sub-contractor shall provide supporting structures capable of carrying the load without distortion, affixed to the building structure in such a manner as not to subject it to undue stress.

2 Supporting of any rotating equipment shall incorporate vibration mountings of the type and selection specified in the applicable clauses referring to equipment bases herein.

3 All methods of suspension or supports shall be submitted to the Engineer for approval and for reference to the Structural Engineer where necessary prior to manufacture or installation.

4 Generally, supports shall preferably be proprietary products such as Unistrut or failing this, shall be of mild steel sections, purpose fabricated for their application. Under no circumstances whatever will sheet metal straps be accepted as a supporting method. All supports shall cradle the item to be supported; supports shall not be rivetted or welded to the equipment to be carried except in exceptional circumstances approved by the Engineer. Rod hangers shall not exceed one meter in length and be of minimum diameter 12mm. For longer suspensions use mild steel angles. Angle iron supports shall be of 25mm x 3mm minimum. All supporting structures for equipment shall be hot dip galvanised.

5 Fastening methods shall employ anchor bolts or their equivalent for fixing supports to the building structure, it not being permissible to utilise gunpowder shot-driven bolts for this purpose unless approval be obtained.

6 Pipework supporting holderbats shall be the product of a recognised manufacturer of such equipment, shop-fabricated saddles or similar devices being unacceptable unless limited space available necessitates their use. On insulated pipework, hardwood inserts consisting of two half-round machine cut pieces of timber shall be clamped around the pipe, insulation being cut away at such points, to allow proper support fitting. Wooden inserts shall be of the same thickness as adjoining insulation and 50mm longer than the width of the holderbat support, to permit correct finishing of the insulation or vapour sealing to them.

7 Cables and flexible pipes shall be supported on Unistrut or equivalent perforated galvanised cable trays, manufactured by specialists, shop-fabricated trays or racks not being acceptable. The cable tray shall be suspended or bracketed using suitable mild steel angles.

4.12. INSTRUMENTS

1 Provide and install instruments where shown on the applicable drawings or mentioned herein as follows:- All instruments shall be installed within Plant rooms where possible and shall be mounted at eye level and, if necessary, remote sensors shall be provided to ensure eye level accessibility. All instruments shall be installed in positions not affected by plant vibration.

2 Instruments shall be of the circular dial type, having equal sized dials between 75mm and 100mm in diameter, unless otherwise specified, and the same finish in copper alloy, stainless steel or chrome plated. All panel-mounted instruments shall be suitable for flush mounting and fixing from within the panels without screws projecting through the panels.

3 Instruments shall be provided with pointers or have painted on their dials green lines to indicate the normal operating ranges of the services indicated and red lines to indicate minimum and/or maximum limits.

4 Air and water temperatures shall be measured with alcohol in glass or mercury type thermometers which shall have a guaranteed accuracy within 1% around the entire dial range and a means for recalibrating the instruments on site. Thermometer ranges shall be suitable for the service and shall not exceed 50% above or below the normal operating temperatures for each instrument.

5 Stems or bulbs sensing temperatures in pipes shall be fitted into oil filled wells and bulbs in ducts or plena shall be neatly fitted on insulated brackets to the satisfaction of the Engineer.

6 Air pressure gauges shall be 50mm dial scaled from 0 to 150% of normal operating pressure.

7 Inclined pressure differential manometers shall be installed to indicate the resistance to the airflow over all banks of filters. Each manometer shall be fitted with a spirit level to ensure proper horizontal mounting and pointers to indicate the initial pressure drop and when the filter media has to be changed.

8 Static pressure indicators shall be of the diaphragm actuated; dial and pointed type graduated to read from 0 to 50% more than the maximum allowable static pressure and shall be installed to sense the leaving main supply duct pressure. The gauges shall be connected to static pressure tips of approved design.

9 Instruments shall be **HUNTER, BMC & WEISS** or approved equal.

4.13. MACHINERY DRIVES

1 Direct drive couplings shall be of the non-lubricated type, rated at least 125% of driving motor horsepower and flexible to allow minor misalignment. "Pin-and-push" type couplings shall not be used, all direct drive couplings being of **FENAFLEX** type FX as manufactured by Fenner or approved equal. Direct drives shall be accurately aligned using the appropriate instruments to within 0,25mm.

2 V-belt drives shall in no case consist of less than two belts and shall be selected in accordance with manufacturer's rating, plus one additional belt per drive. Sheaves shall be machine cast iron with Taperlock shaft bushes all equal to Fenner; aluminium pulleys will not be permitted. All drives on the installation shall be of the same make and of modern high-capacity belt section such as Fenner **ALPHA, BETA,** etc. V-belts shall be fitted in matched sets only.

3 All drives shall be fitted with adequate drive guards complying with the relevant Government regulations, which guards shall be readily removable for access to the drives. Guards fitted to the belt drives shall have an expanded metal face to enable visual inspection of the drive without the need to remove the guard.

4 Propeller, axial flow fans and inline pumps do not require flexible connections.

4.14. NOISE AND VIBRATION

1 Particular care shall be taken in the selection, application and installation of all equipment used to ensure that it operates below the maximum allowed noise levels, specified in the Detailed Technical Specification hereof, and with the least vibration possible, all to the full satisfaction of the Engineer.

2 If still not adequately specified the following general maximum criterion is to be used:

- Bedrooms (after hours) - NC35
- Meeting, Office, Public rooms - NC40
- Public Areas and BOH - NC40
- Plantrooms - NC55
- Basement/Parking - NC60
- Canteen - NC40

3 If any relaxation is desired this is to be discussed with the Engineer, the Engineer’s decision is final.

4 The following measures shall be taken where necessary, whether specifically called for or not all to ensure quiet vibration-free operation of the equipment forming part of the air conditioning and ventilation installations.

5 Rectangular ductwork in the vicinity of critical areas shall be provided with internal acoustic insulation.

6 Anti-vibration cuff connections of flexible joints shall be used on ductwork where it joins vibrating equipment such as fans and air conditioning units.

7 Pipework connecting rotating or vibrating machinery shall be provided with anti-vibration flexible joints, all as previously specified.

8 Equipment shall be mounted on vibration isolators of the correct type and selection, dependent upon deflection requirements versus vibrating frequency.

9 Pipework and ductwork shall be suspended or mounted using suitable supports with vibrating isolators to prevent transmission of vibration from them to the structure to which they are attached, where necessary only.

10 Suitable sound attenuating devices shall be incorporated within ductwork to reduce airborne noise to acceptable levels, as indicated on the Drawings and specified in the Detailed Technical Specification hereof.

11 If in the opinion of the Engineer, any equipment operates with, or transmits from it, objectionable vibrations or noise above the levels specified for the individual areas, it will be necessary to rectify or replace such equipment to the full approval of the Engineer at no additional cost to the Owners.

4.15. REFRIGERATION PIPEWORK

1 Refrigeration piping shall be carried out in seamless, bright, clean refrigeration quality copper tubing and recessed solder joint fittings. Fittings shall be wrought copper or tinned cast brass. Soft annealed tubing shall be used on all pipe sizes below 19mm O.D. whilst hard drawn tubing shall be utilised on all larger sizes. All pipe cuts shall be neatly reamered and cleaned prior to making joints. Silver solder shall be used and tubing shall be protected against oxidation during silver soldering by use of dry nitrogen flowing through the tubing. IF THE DX SYSTEM IS A *VARIABLE REFRIGERANT SYSTEM (VRS)* REFER TO SCHEDULE OF PIPE SIZE, THICKNESS AND TYPE IN THE HVAC PROJECT SPECIFICATION. THE CONTRACTOR MUST STRICTLY COMPLY TO THE VARIABLE REFRIGERANT SYSTEM SUPPLIER / SPECIALIST MANUALS IN TERMS OF INSTALLATION AND STORAGE

2 Liquid refrigerant lines shall incorporate the following components:-

- Bypass flow replaceable type filter driers, of angle type and rated for the full refrigeration duty of the system.
- Y - type full flow strainers.
- Isolating valves of the diaphragm type.
- Moisture indicating type liquid sight glasses.
- Angle type, backseating, capped liquid charging valves with flare charging connections fitted with flare-fitting cap nuts.
- Liquid line solenoid valves.
- Thermostatic expansions valves of the external Equaliser type.

3 Suction lines shall be vapour proof insulated with 35mm thick preformed insulation like **Armaflex**. The insulation lengths shall be applied to the piping as and when the joints are being soldered in order to reduce the joints in the insulation to a minimum. Once the piping has been tested for leaks the insulation joints shall be glued and taped.

4 All visible refrigeration piping and/or exposed to the weather shall be housed within galvanised trunking with a robust protective cover to prevent damage to pipes (e.g. from accidentally stepping on to trays.)

5 Refrigeration pipework shall be supported not exceeding 2,0m centres **or** in accordance with DX equipment manufacturers recommendations. Pipes shall be securely clamped to points of support using suitable holderbats. Insulated piping shall have moulded cork inserts of 35mm thickness and 50mm width in place of normal insulation where supports occur, vapour proofing at such points being carefully executed. Vibration eliminators shall be installed where indicated on the drawings and the piping shall be supported immediately after such vibration eliminator.

6 ll refrigeration pipework passing through walls and concrete floor slabs shall have P.V.C. sleeves of minimum 3mm thickness for the full depth of the wall and/or floor.

7 The sensing bulb of the thermostatic expansion valves shall be securely fastened to the suction line using copper strip and brass screws.

8 Care shall be taken to ensure that pipework is neatly run in straight lines, this applying especially to soft copper tubing. Pipes shall pitch 25mm in 6m in the direction of flow to ensure oil return.

4.16. SMACNA DUCT CATEGORIES

All ducting to comply to this:

SMACNA

REVISED LOW PRESSURE DUCT METAL THICKNESS

CLASSIFICATION : POSITIVE PRESSURE : 500PA

NEGATIVE PRESSURE : 500PA

VELOCITY : 10M/S

Category I/S	Longest Side	SemiPeri-meter	Thickness	Minimum	Maximum Spacing Between Joint	Maximum Spacing	Type	Type of Inter-mediate	Maximum Spacing	Hanger Rod	Hanger Angle mm	Measured Sheet
1	Up to 750	<1150	0.6		2400	2400	S&D	Note 1	2400	6	40 x 2	4.9
2	Up to 750	>1150	0.6		2400	2400	Note 2 Slip on Flange	Note 1	2400	6	40 x 2	4.9
3	751 to 1350		0.8		2400	1500	Note 2 Slip on Flange	Note 1	2400	8	40 x 3	6.5
4	1351 to 2101		1.0		1500	1500	Note 2 Slip on Flange	Note 3	3000	8	40 x 6	8.12
5	> 2101		1.2		1500	1500	Angle ms	Note 3	3000	10	40 x 6	9.75

	Flange or Mezz Flange and Tie Rods

Notes:

1. Sheet Stiffening - Either cross breaking, beading or pleating of longest side to be applied on all ducting where duct dimension is over 550mm

2. Slide on Flanges - Up to 1350mm - 25mm flange, 1351-2100mm 35mm Flange > 2100mm 35mm Flange, and tie rod or mild steel 40 x 40 angle

3. Stiffener -Inverted V strip or equal stiffener fixed on duct side to prevent panels vibrating and sagging.(Tie rods where necessary to prevent drumming, vibration and sagging).

4.17. SOUND ATTENUATORS

1 Sound Attenuators shall be provided and installed in the positions indicated on the drawings and to systems as required even if not shown on the drawings to achieve the Noise Criteria levels specified in the Detailed Technical Specification hereof. Sound Attenuators shall be of factory fabricated type equal to those manufactured by a reputable Sound Attenuation manufacturer equal to **TROX, WOODS, MIS, HOWDEN DONKIN,** and to the Engineers approval.

2 Attenuators shall be of the low loss type with aerodynamic bull nosed splitters.

3 The sound absorbing lining material shall impart no odour to the air, shall not delaminate readily, shall have no loose material or any exposed surface that may be detached by the air stream either during installation or under regular operating conditions. The material shall also be of non-combustible (BS476 1 rating), inert, non-hygroscopic, vermin and rat proof and must not support bacteriological growth.

4 All lining material shall be in good condition at the time of final inspection. Material that has been damaged in shipment by rough handling vibration or exposure, shall be rejected. Material that has been damaged prior to final inspection shall be replaced or coated to prevent detachment of loose material as directed by the Engineer.

5 Sound absorbing lining material generally shall have a density of not less than 16kg per m^3, a thickness of not less than 25mm and sound absorbing efficiency at each frequency of not less than the following:-

Frequency cycles per second	250	500	1000	2000
Percent absorption	45	65	65	80

6 The factory fabricated sound attenuators shall be complete units consisting of an outer casing, sound absorbing material and internal baffles and supports. Casings shall be made of zinc-coated steel, not lighter than that specified herein for ducts of the same outside dimensions.

7 Attenuators are to be constructed of a galvanised steel casing with connection flanges compatible with the flange used on the ductwork.

8 Attenuators used on a kitchen extract canopy extract system are to have splitters protected with a pre-galvanised expanded or perforated metal sheet to which a polyester membrane is added or alternatively Melinex lined.

9 If not adequately specified in the Detailed Technical Specification the following maximum criterion is to be used:

- Bedrooms (after hours) - NC35
- Meeting, Public rooms and Offices - NC40
- Public and BOH areas - NC40
- Plantrooms - NC45-50

10 If any relaxation is desired this is to be discussed with the Engineer. The Engineer's decision will be final.

11 Sound attenuators are to be MELENIX or equal and approved lined for all kitchen extract applications.

12 The attenuating splitter sections are to be fixed to the casing with self tapping screws.

13 Eurolon acoustic media consisting of semi rigid fibre slabs is to be used in the splitters, onto which must be bonded a woven fibre mesh facing.

14 Splitter is to be of the aerodynamic bull nose type, to ensure low pressure loss.

15 Crosstalk (if required- see drawing) attenuators are to be rectangular and a minimum of 1200 long and are to provide a minimum insertion loss of 35 db at 500 Hz at a maximum pressure drop of 15 Pa.

Design based on **Round Sound attenuators connected to Ventilation Fans - Silax-P POD type -**

4.18. STRAINERS

1 Irrespective if shown on drawings or not, the HVAC Contractor shall allow, supply and install pipeline strainers , in isolatable sections, inline to the Chillers, Circulating

Pumps, Air Handling Units, CRAC Units, Heat Exchangers, Fan Coil Units, Water –or Air Cooled Condensing units and elsewhere as indicated on the drawings and standard sketches to equipment supplier requirements.

2 All strainers shall be suitable for the pressure of the system concerned and are to be inspected and tested at the factory prior to dispatch.

3 All strainers shall be of the 'Y' type, class 150 and shall be bronze screwed or flanged, as applicable, up to 50mm diameter and cast iron flanged 65mm and over.

4 All strainers shall be cast iron or bronze bodied of ample strength for the pressure to which they shall be subjected and with suitable flanges or tapping to connect with the piping they serve.

5 Strainer basket screens shall be stainless steel and shall be of ample strength to prevent collapsing of the basket under shock loading. Perforations shall generally be 0.75mm whole diameter with 51 holes per cm2 or depending on protected equipment Manufacturer's requirements.

6 Strainers shall be manufactured to BS, ISO, or DIN Standards.

7 Strainers to be installed as per supplier recommendations.

8 Strainers shall be cleaned

9 Drain down cocks required for strainers larger than 150mm.

10 HVAC Contractor will be held liable to replace free of charge HVAC equipment that is damaged due to non or incorrect sized strainers.

4.19. THERMAL INSULATION CHART & CLADDING SCHEDULE

INSULATION CHART

Sl. No.	**Description**	**Location of Ducting / CHW Pipe**	Insulation Material	**Minimum Insulation Thickness**	**Finishes**
Duct Thermal Insulation					
1	Fan Coil Units, Supply Air- , Return Air Ducting	In air conditioned Spaces	as per specification	13 mm	1. Duct In ceiling : without foil face. 2. Duct In plantrooms or no ceilings : Aluminum Foil Face finish
2	Fan Coil Units, Supply Air- , Return Air Ducting	Non - Air-conditioned Space or Shafts	as per specification	25 mm	Aluminum Foil Face
3	AHU Supply Air / Return Air Ducting	In air-conditioned Spaces	as per specification	13 mm	1. Duct In ceiling : without foil face. 2. Duct In plantrooms or no ceilings : Aluminum Foil Face finish

4	AHU Supply Air / Return Air Ducting	Non - Air-conditioned Space or Shafts	as per specification	25 mm	Aluminum Foil Face
5	Toilet Extract Air Ducting	In air-conditioned Spaces	No Insulation		
6	Toilet Extract Air Ducting	Non - Air-conditioned Space or Shafts	as per specification	13 mm	Aluminum Foil Face
7	Kitchen Extract Air Duct	In air-conditioned Spaces	No Insulation		
8	Kitchen Extract Air Duct	Non - Air-conditioned Space or Shafts	No Insulation		
9	Any Extract Ducting connected to Heat Recovery Section	Non - Air-conditioned Space (Shafts)	as per specification	25 mm	Aluminum Foil Face
10	Transfer untreated outside air duct	In air-conditioned Spaces or shafts	as per specification	13 mm	without foil face
11	Transfer untreated outside air duct	Non - Air-conditioned Space	No Insulation		
Chilled Water Pipe Thermal Insulation					
12	Chilled Water Pipe & Condensate piping & Valves & Fittings Dia up to & incl 5" Dia & condensate pipes	In air-conditioned Spaces	as per specification	19 mm	without foil face*
		Non - air-conditioned spaces or shafts	as per specification	25 mm	without foil face*
13	Chilled Water Pipe & Valves & Fittings 6" - 19” Dia and above	In air-conditioned Spaces	as per specification	19 mm	without foil face*
		Non - air-conditioned spaces	as per specification	25 mm	without foil face*
14	CHW Pipe & Valves & Fittings Dia - Up to 20" Dia (500 mm Dia)	In air-conditioned Spaces	as per specification	19 mm	without foil face*
		Non - air-conditioned spaces	as per specification	25 mm	without foil face*
15	CHW Pipe & Valves & Fittings Dia - Above 20" Dia (Above 500 mm Dia)	In air-conditioned Spaces	as per specification	25 mm	without foil face*

Non - air-conditioned spaces	as per specification	50 mm	with foil face*

NOTE: *

***GALVANIZED / ALUMINUIM CLADDING SCHEDULE**
Refer to specification for minimum thickness

A) DUCTS	AS MENTIONED ON DRAWINGS
B) CHILLED WATER PIPES & VALVES & FITTINGS	IN UNAIR-CONDITIONED AREAS WHERE DIRECTLY EXPOSED TO WHEATHER ELEMENTS OR UV, UNLESS SPECIFIED OTHERWISE ON DRAWINGS, I.E. REQUIRED IN PLANTROOMS ON ROOF.

NOTE:

MINERAL WOOL / ROCKWOOL
Refer to specification

Specification	50mm thick, density =80kg/m3. Must be approved by local authorities, and submitted as such.

4.20. WATER PIPEWORK

1 Water piping systems shall follow the routes indicated on the relevant Drawings. Piping shall be arranged to maintain sufficient headroom, keep access ways unobstructed and not interfere with maintenance and adjustment of valves and equipment. The system shall be complete in all details and provide for all central valves and accessories necessary for satisfactory operation.

2 Where pipe sizes are not indicated on the Drawings, pipes shall be sized for a maximum water velocity of 2,5 m/s within the Plant Rooms and a maximum of 2 m/s for piping extending between the Plant Rooms and the Closed Circuit Coolers or Cooling Towers.

3 Steel piping shall have a minimum thickness equal to schedule 40 to ASTM A53 Standards. Piping for closed circuit condenser water systems shall be of black medium type with welded joints. Galvanised medium steel piping shall be used on all open vented systems such as cooling water type condenser water systems, drainage and mains water supply pipework. It shall not be permissible to weld or burn with a cutting torch any galvanised piping without having it regalvanised by an electroplating process or hot dip process..

4 Long radius bends shall be used wherever possible, elbows only being permissible where limited space dictates their use. Reductions in pipe sizes shall be effected with reducing sockets, bushing reducers not being permissible. Threaded fittings shall be malleable iron to B.S.S. 143 or wrought steel to B.S.S. 1740:1971 as relevant. Welded fittings shall be genuine butt-weld fittings, to ASTM A234 GR.WPB-Dimensions to BS1640 or ASA B16.9 it not being permissible to weld threaded fittings.

4.21. VALVES & INSTALLATION

1 All globe and gate valves (except screwed gate) shall incorporate back seating on spindles to facilitate repacking of gland under pressure.

2 All valves installed shall be of a high standard of manufacture and well known brand equal to **KSB, HATTERSLEY, OVENTROP, HOLMES & CRANE**.

3 Types of valves shall be of the same manufacture.

4 Screwed valves shall be to BS.21 taper.

5 Flanged valves shall be BS4504 standards with connecting flanges to match.

6 ASA Standards will be accepted on steam installations (1050 kPa and over).

7 Screwed valves to be used up to and including 50mm - 65mm and over flanged valves.

8 Valves will be selected to conform to the pressure\temperature rating and duties applicable to the particular system or application where being installed.

9 All valves shall conform to the following material specifications:

- Bronze BS1400 LG 2-C/ASTM B62
- Cast Iron BS 1452 GR 14/ASTM 126 Class B
- Malleable ASTM A-47 GRD 32 510
- Ductile BS 2789 (1961) ASTM or A 395
- Cast Steel ASTM A 216 GRD W C B

10 Gate Valves (if applicable) shall be SABS 776-1975 Class B screwed, or equal, or cast iron body flanged with bronze rising spindle, and trim, outside screw and yoke, solid wedge disc, to BS 5150 J Fig. KF 502 or equal.

11 Globe Valves shall be bronze body screwed, internal screwed bonnet, rising spindle bronze to bronze tapered seats to Conti Fig. 70400 or equal, or cast iron body flanged with bronze rising spindle, and trim, outside screw and yoke to BS 5152 J Fig. KF 501 or equal.

12 Check Valves shall be bronze screwed, swing check type, bronze seats to Conti Fig. 77104 or equal, or cast iron body flanged solid, cast iron flap with bronze trim and bolted cover to BS 5153 J Fig. KF 601 or equal.

13 Alternative Wafer type non-slam check valves central pivoted butterfly flaps with bronze on BUNA N seats to DIN 3202 or API 594 J Fig. KF 301 or equal.

14 Balancing Valves shall be Crane, Tour or Anderson or equal, shut-off\balancing valve with pressure sensing points over the valve for determining water flow rates. All valves to have calibration markings and 65mm and over flanged cast iron Epoxy coated.

15 At all high points of the water systems fit PURG-O-Mat Fig. KS 69 or equal automatic air vents with integral check valves. Each air vent shall be preceded by a gate valve to allow maintenance of the air vents. Automatic air vents shall ensure positive removal of all air from water piping systems. At all low points of the systems fit 15mm diameter drain cocks with hose unions, these valves so located that the entire piping

system can be completely drained. Fit such drain valves at equipment if necessary to allow complete drainage.

16 Closed circuit condenser water and chilled water systems shall be connected to an expansion tank. The tank shall be of adequate size to suit the system and shall be manufactured from 2mm galvanised sheet steel. The minimum water level in the tank shall be kept at approximately 300mm from the bottom by means of a 20mm nominal size ball valve. The tank shall be provided with a separate quick filling connection, overflow and a lid with an air vent.

17 At all equipment connections to vibrating equipment fit flexible connectors equal to Fig. KF 401 as supplied by EM Arnot or Kerr Valves. All flexible connectors shall have flanged joints and be capable of a 16 bar or 1,5 times the system working pressure whichever is the higher value.

18 Copper earthing straps shall be fitted over all flexible connections and shall be carried out in accordance with the standard wiring regulations (see Clause 31.1).

19 Pipe joints shall be neatly made, all pipe cuts properly cleaned and re-amered. At all connections to equipment use flanged joints to conical face unions for smaller pipe sizes up to 40mm nominal bore. Incorporate sufficient flanged joints or unions to allow dismantling of sections of pipework to facilitate access to plant items for maintenance purposes. Use screwed joints of galvanised pipework up to and including 100mm nominal size and on black piping up to and including 50mm nominal size. Where galvanised piping is called for above 100mm diameter use black piping with welded joints and hot-dip galvanised after welding.

20 On black piping all sizes over 25mm diameter may be welded. Screwed joints on piping up to 25mm diameter shall utilise P.T.F.E. jointing tape equal to 3-M manufacture. For larger joints use Hemp and Stag or equivalent jointing compound. Flanged joints shall include Klingerite gaskets or equivalent. Caulking of joints will not be permitted. Connections to equipment where the pipe size is 65mm diameter and above shall be flanged.

21 Plug open ends of pipings, drains, fittings and equipment connections during installation to keep systems free of rubble, dirt and other foreign matter.

22 Maximum support spacing for pipework shall be:-

- 50mm diameter and smaller 2.5 m
- 65 to 100mm diameter 4 m
- above 100mm diameter 4 m

23 All piping systems shall be flushed out properly to ensure cleansing, prior to the operation of the plant.

24 Piping systems shall be tested by means of an hydraulic pump to twice the operating pressure of the system or, where it is not permissible due to the maximum allowable piping working pressure, the piping shall be tested to the limit set by such maximum allowable working pressure. Pressure gauges to be used during normal operation are to be protected when testing occurs.

4.22. PRESSURE INDICATION

1 All dial pressure gauges shall be snubbed or glycerine filled to prevent pointer vibration. Gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure.

2 All inclined manometer differential pressure gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure, with graduation being steps of 10 kPa.

3 All differential dial pressure gauges shall have an accuracy of 2% and shall not be less than 100mm diameter. Zero pressure reading shall be in the centre, and the range of scale on either side shall extend to 150% of the maximum operating pressure, with provision being made for individual pressure reading.

4.23. TEMPERATURE INDICATION

1 All direct reading thermometers and temperature reading devices shall have an accuracy of 0,5°C and a range of -10°C to 10°C for chilled water supply; 0°C to 20°C for chilled water return; 0°C to 40°C for condenser water supply and return, unless otherwise specified, with graduation being in steps of 1°C.

2 Stem thermometers shall be approximately 100mm long and dial type thermometers approximately 80mm diameter.

3 Wells shall be set vertical or at an angle to retain oil. Pipes smaller than 80mm bore shall be enlarged at points where wells are installed as per following table:

- Pipe bore (mm) 15 20 25 32 40 50 65
- Size of enlargement (mm) 32 40 50 50 50 65 80
- The sensor element shall be at the centre of the pipe.

5. EQUIPMENT SPECIFICATION(S)

5.1 AIR HANDLING UNITS

1 Air handling units shall be from reputable AHU suppliers.

2 The Air-Conditioning Contractor is to quote on one make but should he want to put forward a different make this is to be provided as a priced alternative.

3 Units shall comprise of the following components all housed within, or forming part of, their cabinets:-

- Weather louver on direct outdoor air connections (where applicable)
- Direct Expansion Heat Pump or Chilled Water Cooling Coil (where specified)
- Refrigeration or Chilled Water Pipework and Controls
- Backward curved Centrifugal Supply Air Fans with Motor and Belt Drive
- Cleanable , Removable Air Filters
- Internal Electrical Wiring as per SANS specifications

- Hot Water heating coils
- Metal (not plastic) Door handles (door clips not allowed)
- Stainless steel drain pan

4 Internal unit Casings shall be constructed of not less than 1,2mm thick mild steel panels suitably braced and framed so as to prevent drumming while at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic/thermal liner" or equivalent non-combustible material, such insulation being adequately secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

5 External Units are to be constructed from prefabricated panels of laminated foam core. The inner and outer skin maybe 0.6mm galvanised or other suitable pre-coated steel with a chromadek finish or fibreglass.

6 The panel insulation is to be a minimum thickness of 45mm with a conductivity of 0.020 W/mK.

7 Coastal unit casings shall be of suitable corrosion resistant construction throughout and generally in accordance with the above.

8 Tenderers are to note that the unit casing specification above is the minimum required and that preference will be given to units having double skin panel construction.

9 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits. Cooling coils shall comprise copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge galvanised steel casing and fitted with a 1,2 mm thick stainless steel condensate pan so sized and located to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.

10 Cooling coil sizes shall be selected so that the face velocity does not exceed 2,5 m/s and a maximum of 12 fins per 25.4mm (fpi).

11 The chilled water flow through the cooling coil shall be counter flow to the airflow across the cooling coil. The chilled water connections shall be supply at the bottom and return on top.

12 Coils to be used in coastal regions are to be treated with Coreum, Blygold or Bluechem similar corrosion inhibitors.

13 Refrigeration pipework shall be carried out in seamless refrigeration quality piping. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines.

14 Supply air fans shall with impellers running in sealed, permanently lubricated ball-bearing plumber blocks located in the suction eye of each side of each fan.

15 Fan impellers shall be statically and dynamically balanced and run well below critical speed. Fan assemblies shall be so mounted within the air handling unit that they do not transmit any vibration. Where units having more than one fan are offered, these shall all be driven by a common motor.

16 Supply air fan motors shall be three phase squirrel cage type rated not less than 25% above the power input absorbed by the fans and run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of V-belt drive having not less than two V-belts with suitable removable belts guards.

17 The primary air filters shall be minimum 50mm thick high performance washable pleated panel type with an average arrestance of 90% on ASHRAE 52-76 test method. Housed in adequate holding frames and fitted with gaskets to ensure a positive airtight seal around them. The secondary filters, where specified, shall be a minimum 600mm depth high performance bag filters with an efficiency of EU4. Housed in adequate holding frames and fitted with gaskets to ensure a positive airtight seal around them.

18 Internal electrical wiring shall comply fully with wiring regulations as relevant and be adequately secured. Adequate earthing shall be allowed.

19 Both Primary and Secondary filters must be easily removable and properly spaced for full functionality.

REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.

5.2. AXIAL FLOW FANS

1 Axial flow fans shall be of aerofoil type HOWDIN DONKIN, WOODS, PAPST, KRUGER, ZIEHL, NICOTRA, COMEFRI, AMMS, SYSTEMAIR manufacture. They shall be of the size and type as indicated on the Drawings, and shall be capable of the duties specified the Detailed Technical Specification hereof.

2 Fan impellers and hubs shall be of die-cast aluminium alloy and shall be accurately balanced to ensure vibrationless running.

3 The fan casing shall be fabricated from heavy mild steel plate suitably reinforced and fitted at each end with a flange drilled for fixing. An inspection door of ample size shall be provided in the casing.

4 The fan motor with frame diameter matching the impeller hub size shall form an integral part of the fan. The motor shall be of the totally enclosed, squirrel cage type suitable for the supply voltage specified. Motor connections shall be brought out to terminals located in a weatherproof external terminal box that shall be an integral part of the fan casing.

5 Fans shall be resiliently mounted on, or suspended from strong angle iron brackets by means of suitable anti-vibration mountings.

6 Fan speeds shall not exceed the maximum values specified in the Detailed Technical Specification hereof.

7 All ferrous parts of fan components shall be corrosion free and for coastal regions will be suitably protected against corrosion.

5.3. BY-PASS TYPE VAV BOX

1 A Variable air volume, by pass system consists of VAV units connected to the supply air duct of a constant air volume source. A constant air volume of conditioned air is supplied to each VAV unit. The primary damper modulates in response to a zone thermostat demand, to vary the amount of conditioned air delivered to the occupied zone. Damper modulation will range from full shut of to full open position by supplying variable air volume or to a minimum air volume to the conditioned zone. As the primary damper modulates in response to room thermostat demand and once it is satisfied to reduce the air volume to occupied zone, the excess air is diverted through the secondary by pass damper into ceiling plenum or ducted return.

2 Electronic thermostat provide accurate modulating – on/off . Standard supplies is modulating 0-10V.

3 VAV is provided with Belimo controls or equal and approved.

4 VAV By-pass type box shall be equal and approved to Euro Register or equal and approved.

5 Supply and install VAV terminal units of the by-pass type wherever shown on the drawings. Each terminal unit shall be electronically controlled and shall be supplied complete with the following:

6 Casing shall be welded 22-gauge (0.8mm) galvanized steel. Maximum casing leak rate shall not exceed 4% of the nominal rating at 0.5”wg. The unit shall have on primary inlet, one discharge outlet to the room and one by-pass discharge outlet. The casing should also be corrosion resistant.

7 The interior surface of the unit casing shall be acoustically and thermally lined with 12mm 1lb/cu.ft density glass fibre with high density facing. Insulation must meet NFPA 90A.

5.4. CENTRIFUGAL FANS

1 Centrifugal fans shall be **HOWDIN DONKIN, WOODS, PAPST, KRUGER, ZIEHL, NICOTRA, COMEFRI, AMMS, SYSTEMAIR or equal approved** manufacture having capacities as called for in the Detailed Technical Specification hereof and shall be installed in the positions as indicated on the drawings.

2 Centrifugal fans shall be of the multi-vane type with forward or backward curved vanes and be of single or double inlet as specified in the Detailed Technical Specification hereof or as indicated on the drawings.

3 The fan casing shall be fabricated from heavy sheet steel, reinforced and rigidly supported by means of a steel angle superstructure and shall be corrosion free.

4 Bearings shall be of the sleeve, ball or roller type in accordance with the fan manufacturer's standard practice. They shall however be selected and fitted for quiet operation in accordance with the bearing manufacturer's recommendations. Where bearings are located in the air stream, precautions shall be taken to prevent the loss of lubricant. The runners of single inlet fans shall be overhung from outboard bearings.

5 The fan wheel and shaft shall be statically and dynamically balanced and designed to prevent vibration at the required operating speed. This operating speed shall be well below the first critical speed.

6 Fan drives shall be by means of V-belts and grooved pulleys. Fan motors mounted on the fan housings are not acceptable. Removable belt covers are to be provided.

7 Large fan housings shall be made up in sections to permit installation through available openings in the building.

8 Fan shafts shall be of steel and shall be properly protected against corrosion by means of suitable wrappings and protective grease coatings.

9 All ferrous parts of fan components shall be corrosion free and for coastal regions will be suitably protected against corrosion.

10 All fan casings shall be fitted with removable airtight access panels, to ensure maintenance inspections of fan internal casings.

11 For kitchen extract installations single inlet fans are to be used, expected where explicitly indicated on the drawings. In addition to the normal spare parts provisions as per clause 32 a spare motor is to be provided.

5.5. CHILLED WATER FAN COIL UNITS

5.5.1 GENERAL

1 To be read with other related sections of Contract Documents

2 Manufacturer: Fan coil units shall be from reputable supplier.

3 Noise levels: The final noise levels shall not exceed the following:

4 NC 35 at medium speed measured at 1m horizontal distance from the return or supply openings, when operating at an external pressure of 50Pa and room effect of 8db 1.8m above the floor. To limit the noise levels within these parameters, if the supplier intends to provide silencers, then the sound insulating material shall be moisture protected mineral wool.

5 Electrical supply type: Single phase as per drawings.

6 Access: Provide access to filter, fan and motor drip tray, valves and controls.

7 Drip tray:

- Position: Under coil, and under strainer.
- Material: Corrosion resistant.
- Condensation: Insulate external faces to prevent condensation.

8 Controls: Control valves shall be modulating type two way.

9 The valve size and control valve shall be selected such that at design flow rate the pressure drop across the valve will not provide a valve authority over the FCU sub circuit of minimum 0.35 and maximum of 0.5.

10 The valve selection shall be such that it will not cause objectionable noise in the bedroom application throughout its operating range from 0 to 100% opening.

11 The valve actuator shall be able to close against the applicable system pressure differential.

12 Connection of the valve package to the FCU shall be with high pressure braided hose flexible connections.

13 Valve package to include:

- Isolating ball valves, supply and return.
- Flushing bypass with ball valves.
- DRV balancing valve.
- 2-way control valve.
- 14 Units shall be complete with chilled water coil(s) fan(s), motor(s), insulated drain pan and all required wiring, piping, controls and special features.
- All FCU coil selections to be based on chilled water 4.5*C delta T
- Horizontal base unit with plenum for concealed installation shall have a factory installed, galvanized steel plenum section and cleanable filter. The plenum shall be rear return, lined and include removable panels to provide access to the fan / motor assembly. The plenum shall have locating arrangement to retain the lint screen filter and prevent the bypass of unfiltered air.

16 Horizontal cabinet unit shall be lined with 12mm thick glass fibre insulation and have removable bottom access panel and having the height not exceeding 450 mm.

17 Fans shall be direct driven, double width fan wheels shall have forward curved blades, and be statically and dynamically balanced.

18 Fan motors shall be 3 speed permanent split capacitor type.

19 Standard base unit shall be equipped with a 4 row coil (minimum) for installation in a 2 pipe system. Coils shall have 9mm copper tubes, aluminium fins (12 fins / inch) bonded to the tubes by mechanical expansion and have a working pressure of 16 bar. Each coil shall have a manual air vent drained back to the drip tray.

20 The drain pan shall be constructed of stainless steel extending the entire length, including under the valve package and full width of the coil and pitched for drainage. The outside surface of the drain pan shall be covered with closed cell fire retardant neoprene insulation, that will prevent condensation under application.

21 Unit manufacturers shall have ISO 9001 certification. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation.

22 All equipment wiring shall comply with NEC requirements.

23 Unit capacity ratings shall be certified in compliance with industry standard 441-56 for equipment, testing and rating of fan coil air conditioners as administered at A.R.I. Entire unit shall be Underwriter's Laboratory listed and comply with National Electric code. When units do not have A.R.I. certified ratings, and if the engineer insists, the contractor must perform capacity tests of the completed installation, which are witnessed by the Engineer, to confirm specified capacity is achieved while not exceeding specified sound power levels.

24 No materials shall be used, that encourages the growth of bacteria and fungi in the presence of moisture.

25 Fan Coil Units shall be selected at suitable speeds to provide the specified capacities at medium speed against the system resistance specified.

26 The maximum coil face velocity of the Fan Coil Unit not to exceed 300 fpm (1.5 m/Sec).

27 In some cases, refer drawing, provide a PRV (Pressure Reducing Valve) to risers feeding Fan Coil Units.

5.5.2. INSTALLATION

1 A ceiling access panel to be provided below the Fan Coil Unit to allow access to the FCU components including chilled water and drain connections, valves, drain traps, electrical and control connections and components, etc. Access is required for general maintenance and commissioning purposes. The minimum size for the access panel is 600mm x 800mm.

5.5.3. FAN COIL UNIT DRAIN LINE

1 Drain connections: Connect drain line flush with bottom of drip tray.

2 Drain line material: Copper.

3 Provide all necessary drain piping laid to suitable falls.

4 Provide a clearable trap at the connection to the FCU drain pan.

5 All drains from FCU drain pans for condensate disposal shall be fitted with a flexible connection where connected.

6 Drainage pipework of longer than 4,5m run shall be provided with cleaning eyes on all bends to facilitate maintenance.

7 The condensate drainage pipework from each unit to be 32 mm diameter copper.

8 Each condensate drain to be insulated with 15 mm thickness armaflex insulation and run in the ceiling void to the nearest soil vent pipe.

9 A 150 mm deep soil trap to be provided at the connection point to the drainage stack, alternatively to be connected on the incoming end of the nearest WHB bottle trap.

5.6. CHILLED WATER GENERATORS: AIR- & WATER COOLED

5.6.1. DESIGN, MATERIALS, FINISH AND MAKE

1 Chillers shall be of standard, factory assembled packaged type and the design, material and finish shall be equivalent to a well-known make approved by the Engineer.

2 The refrigerant to be used shall be R134A, R407C or R410A with zero ozone depletion potential, unless otherwise specified in Detailed Technical Specification

3 The chillers shall be equal to **CARRIER, TRANE, HITACHI, and DAIKIN, STULTZ, HIREF, CLIMAVANETA, CLIVET, CIAT,**

4 Supply and installation must comply to ASHRAE Standard 15-2004 for Safety Standard for Refrigeration Systems.

5.6.2. CAPACITY

1 The cooling capacity as specified in the Detailed Specification shall be delivered in accordance with the relevant ARI specification.

- ARI – 590-92
- ARI – 550-92

2 The fouling factors used when selecting chillers shall not be less than the following:

- Condenser Tubes : 0.088 m² K\kW
- Chiller tubes : 0,044 m² K\kW

3 The maximum permissible saturated condensing temperature is 40,6 °C.

4 The minimum permissible saturated suction temperature is 1 °C.

5 The minimum permissible sub-cooling of the refrigerant is 6 °C at full load.

5.6.3. COMPONENTS

1 The chiller shall comprise the following:

- One or more Centrifugal, reciprocating or screw compressor;
- One or more evaporator;
- One or more air-cooled or water cooled condenser (refer Detail Specification and or Equipment Schedule); If air-cooled, Pre-coated condenser coil and fins
- All necessary refrigeration Pipework;
- Accessories as listed;
- Control equipment as listed;
- Frame;
- Compressor motor drive
- Electric Switchpanels, switchgear, Controls and Safeties to IP44 (inside) and IP54 (outside), with diagnostics function.
- Internal electrical wiring.
- High quality anti-corrosion treatment on all components as standard. All panels to be pre-painted.
- Stainless steel plate heat exchanger on packaged chillers or all aluminium micro channel heat exchanger (MCHX) with increased corrosion resistance. Confirm this with the engineer in writing.
- Chillers above 350kW to have PED certification on Heat exchangers.
- If installed in an open to atmosphere plantroom,.
- Air-cooled chillers to be low noise level option as standard.
- Chillers that are installed in an open plantroom that are exposed to atmosphere, must be installed as standard with enclosure panels, water heat exchanger frost protection, main disconnect switch and hail guards.

5.6.4. COMPRESSOR

1 The compressor(s) shall be of the Centrifugal type or screw type or of the open or semi-hermetic reciprocating type (refer to Detailed Project Specification and/or Equipment Schedule for type) with built-in cylinder head by-pass controlled by either suction pressure or external signal in a number of steps as specified in the Detailed Technical Specification.

2 The compressor shall be fitted with suction and discharge valves and crankcase heater.

3 The compressor shall be direct driven at a speed not exceeding that of a four pole motor. A sight glass for checking oil level shall be fitted in the crankcase.

5.6.5. AIR-COOLED CONDENSER

REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.

1 The condenser(s) shall be of the multi-pass tube and fin type constructed in accordance with the relevant ASME code. The condenser(s) shall be equipped with a pressure relief device and liquid line isolating valve.

2 The condenser(s) shall be circuited to give the sub-cooling specified and shall be fitted with a device with which the liquid level within the condenser can be readily and reliably checked whilst the machine is on load.

3 The condenser heat exchanger shall be corrosion treated with Coreum, Blygold or equal and approved treatment.

4 The fin spacing will need to take into account heavy dust/sand loading, (desert location) as well as the abrasive nature of the expected dust/sand.

5.6.6. WATER COOLED CONDENSER

REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.

1 The condenser(s) shall be of the multi-pass shell and tube type constructed in accordance with the relevant ASME code. The condenser(s) shall be equipped with a pressure relief device and liquid line isolating valve.

2 The condenser(s) shall be circuited to give the sub-cooling specified and shall be fitted with a device with which the liquid level within the condenser can be readily and reliably checked whilst the machine is on load.

3 The condenser(s) shell shall be fitted with either a marine type water box or shall be connected to external piping in such a way that the water box covers can be easily removed.

4 The maximum permissible velocity of water in the tubes is 3m/s

5.6.7. EVAPORATOR

1 The evaporator shall be of direct expansion type with refrigerant flowing in the tubes and water in the shell.

2 At factory, the shell shall be lagged with a minimum of 25mm non-combustible insulation, vapour sealed and finished with a durable outer protection.

5.6.8. REFRIGERANT CIRCUIT(S)

1 Must have a leak tight refrigeration circuit. Each circuit shall include the following components:

- Refrigeration Pipework in accordance with Clauses of this General Technical Specification.
- Expansion Valve
- Liquid line solenoid valve
- Re-changeable filter drier.

- Sight glass situated above the operating level of the liquid in the condenser.
- Liquid line shut-off valve.
- Hot gas muffler.

5.6.9. INSTRUMENTATION

1 The unit shall be fitted with gauges or other suitable electronic display device to indicate suction pressure, discharge pressure and oil pressure for each compressor.

5.6.10. CONTROL AND ACCESSORIES

1 The unit shall be wired with all necessary control in a separate enclosure. The following components shall be included:-

- Crankcase heater control to operate when the compressor stops.
- Non-recycling pump down relay.
- Timer to prevent compressor cycling in less than five minutes. (Units above 40kW refrigeration capacity only).
- Transformer if controls are to operate at less than mains voltage.
- High and low pressure cut out, the former with manual reset.
- Oil pressure cut out with manual reset.
- Unloaders to bypass cylinder heads on start-up, on reciprocating compressors.
- Low water temperature safety protection.
- Chilled water leaving temperature control set to operate with a minimum of four steps in units above 200 kW refrigeration capacity and in two steps in units above 100 kW refrigeration capacity.
- Compressor motor overcurrent safety
- Fan Thermal Protector Safety
- Reverse Phase protector
- Internal fuses for each circuit

6.6.11. MOTOR

1 The compressor(s) shall be driven by a three phase squirrel cage induction motor(s). The motor(s) shall have sufficient power and torque for all operating conditions on the compressor(s).

2 The motor(s) shall have four or six poles. Where open compressor(s) are used, standard protected drip proof or totally enclosed fan cooled motor(s) shall be fitted.

5.6.12. DRIVE

1 Where open compressor(s) are used the motor(s) shall be direct coupled to the compressor(s) by a flexible drive. A protective coupling guard shall be fitted to each drive.

5.6.13. FRAME

1 Components shall be mounted on a rig frame such that any major component can be readily removed without removing other components. The base holding the motor-compressor shall be sufficiently rigid to prevent any torsional or lateral vibration or misalignment between the motor and compressor shafts.

2 Anti-vibration mounting shall be in compliance with Clauses of this General Technical Specification.

5.6.14. PLANTROOM

1 Only if the chiller are installed in a enclosed plantroom (i.e. not open to atmosphere), the plantroom is to be supplied with a refrigerant gas monitoring and ventilation system as specified in the latest ASHRAE Standards. Contractor to include this in their costs during tender stage.

2 The refrigeration/chiller plant installation is to be supplied with a gas purge and reclaim system as described in the latest ASHRAE Standards.

5.6.15. GENERAL

1 Units are to be run tested before shipment. Installation, storage & commissioning must be in strict accordance with manufacturers' specifications.

2 Tender Costs must include delivery to site.

3 Chiller prices are to include commissioning and all consumables for commissioning inclusive of a full refrigerant charge.

4 Chiller must have excellent part load energy efficiency

5 Any software associated with the chillers must be linkable to a BMS.

6 If the engineer agrees, alternative prices may be submitted under separate cover for alternative numbers / mix of chillers if more economical however these must be accompanied by a full comparison of critical data inclusive of capacity, power consumption, pressure drops, dimensions, additional piping and electrical costs, etc.

7 Tender costs must include for the supply installation and commissioning of a Computerised Chiller Management System to control the group of chillers, or the single chiller if only one chiller.

5.7 CHILLED WATER SYSTEM PRESSURISING AND EXPANSION

1 The Contractor shall supply, install, test and commission an expansion and pressurisation system to the chilled water system to cope with the expected water expansion created by a complete chiller plant shut down. This system shall be connected to the suction side of the primary chilled water recirculation pumps to maintain the system neutral point at these pumps.

2 As a minimum a suitably sized open GRP sectional panel tanks can be provided at the highest point with in the building complete with float valve operated make-up

supply off the domestic water mains and relief valves at strategic points to maintain the system between safe operating limits. Should this not be possible then a mechanical pressurisation and expansion system must be provided.

3 The set shall consist of a steel enclosure, protected against corrosion, into which the main components excluding the pressure/expansion vessel shall fit. The enclosure shall have a hinged door, break-tank with loose lid, ball-valve. In addition to this, the set shall have the following:-

4 Test "button"

- System isolating valve to enable commissioning of the set prior to opening to the system
- Multi-volt transformer to provide the necessary signal voltages
- Pressure transducer and lead
- All necessary interconnecting pipework in light gauge copper to BS.2871, Table 'X' and non return valves etc.
- Two pumps operating on a duty/standby basis.

5 The entire system shall be controlled by a Microprocessor which must give alternate pump starting on two pump sets, pump start frequency/leakage detection alarm to indicate a leak causing too many starts per hour, thus damaging the switchgear etc., high and low pressure alarms manual reset, a common alarm to shut down the system if the pressure limits are transgressed, indication of transducer or transducer lead faults.

6 Volt free contacts MUST be provided for the following:-

- Common system alarm and system OK status, high pressure alarm, low pressure danger alarm, pump start frequency. These volt free contacts for connection to a future BMS. System expansion vessel(s) to be steel "water in bag" type of correct size to suit system parameters with an air cushion pressure to match "Initial System Pressure." These vessels shall be mounted external to the enclosure.

7 System Parameters:-

Static Head (Highest part of system above unit.)	-
Flow Temperature	degree C
Return Temperature	degree C
Content Approximately	litres
(Actual content to be calculated by Contractor from approved working drawings)	
Maximum Working pressure	minimum 10 bar for low rise buildings minimum 16 -25bar for high rise buildings and TO BE double checked and CALCULATED BY HVAC CONTRACTOR TO SUIT THE PURPOSE.

8 The following additional requirements to be provided.

- Door interlock isolator
- Under voltage relay

- Break tank low water level
- Warning and danger alarms

- Hours run meters for each pump
- Pump suction strainers
- Pump Isolating valves.

9 The pressurizing unit shall be manufactured by a manufacturer having a fully established and authorized Local Agent able to provide a fully comprehensive after sales service.

5.8. CHILLED WATER TREATMENT & FILTRATION

5.8.1. GENERAL

1 A suitable chemical treatment and mechanical water filtration system shall be provided. The system shall be equal and approved to that supplied by **PWM, AWA, CULLIGANS , AQUALEX** and shall be SABS approved.

2 The system does not necessarily need to be a permanent installation as the pipework network shall be a closed system, but provisions need to be made for plant space, plinths, conductivity monitoring system and connections to the pipework network that will allow the connection of the necessary equipment to bring it back to acceptable limits.

3 The acceptable limits for the water quality shall be as follows:-

Water Condition	Acceptable limits
1. Ph	9.0 – 9.5
2. Fe content	<1
3. Chloride	Max 800 ppm
4. Molybdate	30 to 70
5. Suspended Solids (NTU)	<150
6. Total Hardness	80
7. Alk. (M) & Alk. (P)	100
8. TDS	150

4 The Contractor shall carry out thorough cleaning of the entire chilled water pipework system and shall allow the following minimum procedures in conjunction with the Supplier’s recommendations:-

5 Refer to CIBSE Commissioning Code W, including the following:=

6 Fill the entire system with fresh water from the bottom to the top, and add a recognized and approved cleaner in sufficient quantities as recommended by the Supplier, taking necessary samples for analysis during each flushing

7 Operate the system for at least 6 hours or as per Supplier's recommendation taking samples for analysis every 2 hours. Temporary shall be required for this purpose as required.

8 Thoroughly flush the system for as many times as is necessary to remove all traces of pre-operational cleaning chemicals and as recommended by the Supplier taking necessary samples for analysis during each flushing.

9 Refill the system with fresh water and add an oxygen scavenger and corrosion inhibitor in adequate quantities as recommended by the Supplier, to suit the overall system volume.

10 The Contractor shall follow the written instructions of the system Supplier for the mixing of all chemicals and a copy of these shall be kept on site in the O&M manuals.

11 The system supplier shall include in their price for the first year comprehensive maintenance, spare parts and service to maintain optimum generator performance, efficiency and system water quality.

12 An appropriate corrosion rack shall be provided by the contractor for the first three months. The contractor shall conduct 30-day corrosion coupon analysis on carbon steel & copper as per ASTM standards, and shall report coupon analysis results to the engineer, as requested. A microbiological evaluation to access control on microbiological load in the system shall also be conducted in this initial period.

13 The Water Treatment Program shall fulfil the requirements for both open and closed water circuits as listed below.

14 The Water Treatment Program must inhibit scale, corrosion, fouling and microbiological growth.

5.8.2. CORROSION INHIBITION

5.8.2.1. Pre-treatment Program

1 Once the Water Circuits have been completed and are ready for pressure testing, the water treatment company must implement a Pre-treatment Chemical program – equivalent to ***PWM*** **Pre-KLEEN CT**. This program must be capable of removing oils, greases, mill scale, flash corrosion and any other foulants, as well as passivating the metal surfaces, prior to or during the pressure testing phase.

2 No untreated water should be allowed to enter the systems during any phase of construction.

3 The water treatment company must submit a detailed report outlining the product to be used, on-site requirements, length of time for the pre-treatment/cleaning process as well as the parameters to be measured during the procedure.

5.8.2.2. On-Going Water Treatment Program

1 The on-going water treatment chemical program must inhibit corrosion of all metal surfaces present in the system.

2 No chemical program will be allowed that contains chromates or any substance/s that are limited by the local authorities or might be harmful to the environment.

3 Preference will be given to an all-organic program, ***PWM* Towergard 8000** Series or equivalent for open recirculating cooling waters, and to nitrite based programs, ***PWM* Towergard 9000** Series, or equivalent for closed loop circuits.

5.8.3. SCALE INHIBITION

1 The chemical treatment program implemented on the open recirculating and closed loop systems shall prevent the build-up of adherent mineral scale on heat transfer surfaces.

2 The Chemical program for the open recirculating circuits must also optimise water usage, by maintaining a minimum of 5 cycles of concentration in the recirculating water, or being able to operate at a minimum of 500ppm Total Alkalinity and 1000ppm Total Hardness.

3 No chemical program will be allowed that contains chromates or any substance/s that are limited by the local authorities or might be harmful to the environment.

4 Preference will be given to an all-organic program, *PWM* Towergard 8000 Series or equivalent for open recirculating cooling waters.

5.8.4. MICROBIOLOGICAL CONTROL:

1 The microbiological program implemented on the open and closed loop circuits must inhibit the growth of algae, fungi and bacteria. Total plate counts must be maintained below 10000 at all times.

2 The biocide program implemented on the systems must be geared to reduce the risk of Legionaires' Disease and a contingency program must be submitted to outline procedures that will be undertaken should Legionella be detected in the system waters.

3 No chemical program will be allowed that contains chromates or any substance/s that are limited by the local authorities or might be harmful to the environment at their given dosages.

5.8.5. FOULING CONTROL:

1 Should the environment where the open recirculating water circuit cooling tower is situated be in a "dirty" environment then the water treatment company must make recommendations to limit the build-up of solids in the system. This should include both chemical and/or mechanical methods i.e. fitting of sand filters, cleaning frequency of cooling tower sumps, implementation of a chemical dispersant program etc.

5.8.6. DOSING AND CONTROL EQUIPMENT:

1 In order to ensure that the water parameters and chemical programs are automatically maintained within the desired limits the following dosing and control equipment must be supplied:

5.8.6.1. Open Recirculating Circuit:

1 Each Open Recirculating Cooling circuit must have proportional chemical dosing of the corrosion/scale inhibitor as well as automatic dosing of the biocide program. In addition the recirculating waters Conductivity/ TDS must be automatically controlled and must have an audible alarm should the water go out of the pre-set parameters as well as a digital readout of the set parameters and system TDS/Conductivity.

2 The recommended equipment is the ***PWM*** **TOWERTRAC I or AWA** or equivalent and approved.

5.8.6.2. Closed Loop Circuit:

1 The circuit should be fitted with an impulse flowmeter and chemical dosing pump, for the proportional dosing of the scale/corrosion inhibitor chemical. In addition a pot feeder should be fitted to the circuit for the addition of the biocide program.

2 The recommended equipment is the ***PWM*** **Auto-TROL C/L or AWA** or equivalent and approved.

5.8.7. MONITORING AND CONTROL:

1 The Water Treatment Company must supply a technical support service that will ensure that the water treatment program operates within its set limits.

2 On at least a monthly bases the recirculated waters must be sampled and tested in order to ensure that the following conditions are maintained within the circuits:

3 Biological counts are maintained at no greater than 10 000 and no visible signs of algae or slime in the cooling towers. Legionella testing must be performed by an SABS approved laboratory 6 monthly.

4 Mild Steel Corrosion rates are maintained at <1mpy in the closed systems and <5mpy in the open recirculating systems.

5 No adherent scale build-up is occurring on the heat transfer surfaces.

6 There is no build-up of silt in the cooling tower sumps.

7 Water usage in the systems is optimised – at least 5 cycles of concentration, or a Total Alkalinity of 500ppm and or Total Hardness of 1000ppm in the open recirculating waters.

8 Water meter readings and chemical consumption must be submitted monthly.

9 Equipment dosing rates must be monitored and the equipment calibrated monthly.

10 The Water Treatment Company must have a response time of no longer than 24hrs to water related problems on the plant.

11 A service report must be generated on-site, by a technically competent representative outlining his findings and recommendations. This report must be handed to and discussed with the nominated site representative.

5.9. CLOSED CIRCUIT COOLERS

1 Closed Circuit Coolers shall be of sufficient capacity to match the heat rejection requirements of the Water Cooled packaged air conditioners or chillers whilst being selected in accordance with the air entering wet bulb temperature given in the Detailed Technical Specification herein.

2 Closed Circuit Coolers shall be of the induced or forced draft type, rectangular in shape, of galvanised sectional steel construction and shall be **EVAPCO, BALTIMORE** Closed Circuit Coolers**.**

3 The Closed Circuit Cooler sump and main supports shall be constructed of hot-dip galvanised steel with a minimum thickness of 1.8mm. Reinforcing angles and channels shall be 4mm thick hot-dip galvanised steel. Standard sump accessories shall include access doors, stainless steel strainers, and brass make-up valve with unsinkable, foam filled, plastic float.

4 Fans shall be of forward curved centrifugal type, statically and dynamically balanced. The fans shall be mounted on either side of a solid steel shaft with forged bearing journals. Shafts with welded journal construction or centre bearings shall not be permitted. The fan shaft shall be supported at each end by heavy duty re-greasable self-aligning ball bearings in cast iron housings.

5 Driving motors serving the closed circuit coolers fans shall be of the drip proof squirrel cage type and run at a rotational speed not exceeding 1500 r.p.m. The motor shall be mounted on an adjustable base external to the unit for ease of service and maintenance. The V-belt drive shall be designed for not less than 150% of the motor nameplate power rating. The motor and drive shall be installed with a protective canopy.

6 The cooling coil shall comprise of steel tubing circuits supported by a heavy steel frame. The assembled coil shall be tested at 2400 kPa air pressure under water to ensure that it is leak free. The airflow through the coil shall be counterflow to the water flow and the tubes of the coil shall be staggered in the direction of the flow to obtain a high film co-efficient. To protect the coil against corrosion the entire tubing and frame assembly shall be hot-dip galvanised.

7 The spray header and branches shall be constructed of Schedule-40, polyvinyl chloride pipe for corrosion resistance. The branches shall have removable plugs in the ends for cleaning purposes. The water shall be distributed over the coil by precision moulded spray nozzles with large 9,5mm by 25,4mm orifice openings to eliminate clogging.

8 Eliminators shall be constructed entirely of inert polyvinyl chloride in easily handled sections. The eliminator blades shall be spaced on 25,4mm centres and shall incorporate three changes in air direction to ensure complete removal of all entrained moisture from the discharge air stream. They shall have a hooked leaving edge to direct the discharge air away from the fans air intake to minimise recirculation.

9 Closed circuit coolers installed at the coast shall be coated with Power Bond II finish (cold tar epoxy coating) or equivalent, for maximum protection against corrosion. All paintwork shall be made good as required once the closed circuit cooler has been installed. Alternatively casings constructed from fibreglass will be acceptable.

REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.

5.10. DIRECT EXPANSION HIDE-AWAY SPLIT UNIT (non Variable Refrigerant System)

1 DX Fan coil units shall be **Daikin**, **Trane**, **Mitsubishi**, **Carrier** , **Samsung, Ecoaire,** or equal and approved.

2 The casing and fan is to be constructed of galvanised steel and the coil of copper tubes and aluminium fins mechanically bonded to the coil. The fins shall be surface coated with a corrosion inhibiting substance, preferably factory applied.

3 Fan motor, scrolls and wheels to be easily removable in-situ.

4 The unit casing is to be insulated with minimum 10mm high-density self-fire extinguishing material.

5 Each unit is to be fitted with a return air plenum and washable filter.

6 Units are to be supported on anti-vibration mounts or rubber “grommets” to prevent vibration being transmitted into the slab over.

7 Units to be provided with extended insulated drip trays and catch trays where servicing and control valves are installed.

8 Condensate drains to be provided with suitable trap to prevent transfer of smells from the drainage system and where possible is to use the trap of a wash hand basin. A short length of transparent tubing is to be provided at the connection to the drain pan. All drain lines are to be insulated and at a suitable fall to prevent standing water.

9 Condensing units should insulated with 10mm Armaflex or Kaiflex and be positioned to manufacture’s specifications, including correct spacing around and above the condensing units.

10 The HVAC sub-contractor to ensure that the hide away unit selection takes the pressure drop over the VAV-Box into account. Detail calculations to be submitted to the Consultant.

11 The successful contractor will be responsible for the DX Hide Away Split Units as well as the equipment selections.

12 The schemes indicated on the tender drawings are indicative only of the preferred ducting and piping routes co-ordinated by the Professional Team.

13 Design criteria has been supplied in this document as a brief. As part of the design development, the successful contractor will have to ensure that the design of the Air-conditioning system abides by the regulations laid down by the Municipality, the Local Authorities and the NFPA.

14 The Contract, as detailed in these Specification Documents and the accompanying drawings, comprises of the design development, as well as the manufacture, supply, transport and delivery, hoisting, installation, testing, setting in operation, leaving in complete working order, guarantee-component replacement of the entire air conditioning plant and, except so far as the contract otherwise provides, the provision of all labour, materials, contractor’s equipment and everything, whether of a temporary or permanent nature required in and for such manufacture, supply, off

loading, hoisting, installation, testing, setting in operation, leaving in complete working order, guarantee so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract. The HVAC sub-contractor is responsible for selecting all direct expansion split units, which are to meet the specified cooling capacities at the design on coil and ambient conditions. All refrigerant pipe sizing, positioning of all condensing units and the responsibility for ensuring that the manufacturer's maximum recommended refrigerant piping length is not exceeded, remains the HVAC sub-contractor's responsibility. A fully comprehensive warranty is to be provided on all compressors for a minimum of three years after the project completion date as part of this tender. It is the HVAC sub-contractors responsibility to ensure that all condensing units are positioned in the proposed plantrooms as indicated on the tender drawings. The HVAC subcontractor is to ensure adequate ventilation is achieved and to comply with the manufacturers specifications. The HVAC subcontractor must ensure that there is no recirculation of heat from the condensing units discharge air.

15 The following related work to the air conditioning and ventilation (HVAC) sub-contract will be provided by others. The HVAC sub-contractor shall be responsible for the detailing, checking and ensuring that the work as listed in the schedules and shown in principle on the drawings is provided as per his detailed builder's work and related services drawings.

16 Instructions for the HVAC sub-contractor's exact requirements shall be transmitted to the Principal contractor and the other sub-contractors timeously in the form of builder's and associated services drawings in accordance with an agreed programme. Should these instructions be issued after the completion of relevant areas, then this work will be carried-out at the expense of the HVAC sub-contractor.

5.11. ELECTRIC MOTORS

1 All electric motors on the installation shall be of one make unless forming an integral part of the equipment served and shall not operate in excess of 1500 r.p.m. unless approved by the Engineers for specific applications. Motors shall be **SIEMENS, ABB, GRUNDFOS, SPP, WEG** or approved equal.

2 Motors shall be 400 volt, three phase, 50 Hertz for all sizes from 0,4 kW upwards. Smaller motors may be 230 volts, single phase, 50 Hertz.

3 All motors shall be of the totally enclosed, fan cooled type and have metric frame dimensions. Motors shall be quiet in operation and corrosion free to the full acceptance of the Engineers.

4 All electric motors for outdoor condensing units shall be of the weatherproof type and all motor components shall be corrosion free.

5 Three phase motors shall all be squirrel cage induction type with special high torque motors being used on high inertia loads such as large centrifugal fans.

6 Starting methods for three phase motors shall be in accordance with local regulations. In the event that these regulations are not available at the time of tender, the following starting methods shall be allowed for:-

- Motors up to 5.5kW direct-on-line
- Motors above 5.5kW Star-delta
- Motors above 22,5kW Auto transformer started in three controlled steps

7 Single phase motors shall be capacitor start, induction run type with built-in manual reset overload protection.

8 The nameplate rating of electric motors shall be at least 15% greater than required on motors below 15kW. On larger motors a 10% margin shall be allowed.

9 Motors & Wiring standing outside in open shall be IPP 55 Rated, and shall be selected not to overheat.

5.12. ELECTRODE HUMIDIFIERS

1 Electrode type, steam-generating humidifiers shall have the capacities as called for in the Detailed Technical Specification herein.

2 Humidifiers shall be installed in full accordance with their manufacturer's instructions and their steam injection nozzles fitted in the positions indicated on the Drawings.

3 Humidifiers shall be piped to suitably selected steam injection nozzles each being of sufficient length so as to extend over the full length of the coils or the ducts, or be the maximum standard length available for the manufacturers of the humidifiers, and positioned for optimum mixing of the steam discharge with the air without condensate forming on any adjacent casings or inside the supply air ducts. Should steam distribution hosing runs, because of their length, cause excessive steam temperature drop and a consequent high rate of condensate within them, then the hoses shall be insulated with suitably sized light density, performed fibreglass sectional lagging covered with P.V.C. plastic sheeting overlapped over each section and fixed with approved adhesive.

4 Each humidifier shall be supplied with two sets of spare replaceable electrode elements.

5 Water connections to and drain connections from the humidifiers shall be carried out in water quality tubing using compression type fittings. The mains water serving the humidifiers must NOT BE TREATED and shall be taken from the mains water supply connections to be provided by others in each plant room in the positions indicated on the drawings.

5.13. FIRE / SMOKE DAMPERS

Acceptable makes: **TROX**
BLENDAIR
VENTLINE

1 The nameplate rating of electric motors shall be at least 15% greater than required on motors below 15kW. On larger motors a 10% margin shall be allowed.

2 Motors & Wiring standing outside in open shall be IPP 55 Rated, and shall be selected not to overheat.

5.13. ELECTRODE HUMIDIFIERS

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5.14. FIRE / SMOKE DAMPERS

Acceptable makes: **TROX**
BLENDAIR
VENTLINE

1 Fire Dampers are to be of the combined volume control/fire type with a two hour rating

2 Dampers are to be complete with a reusable thermocouple thermal link and a 24 volt A.C / D.C actuation device.

3 Must be SABS certified.

4 Comply to SANS 10400-2011 TT43 and SANS 193

5 Damper motors will normally have power on to hold open and power off - spring return - to close.

6 All operation and control components shall be external and the thermal link shall release at 72ºC in addition to the thermocouple thermal link. Actuated combination.

7 HVAC contractor to provide all fire dampers complete with actuators along with a central MCP per floor and ELV reticulation from the MCP to Fire Damper actuators.

8 All wiring to be failsafe. I.e. Power to open.

9 Fire consultant to provide fire signal to the HVAC fire damper MCP.

5.15. IN-LINE CIRCULAR DUCT CENTRIFUGAL FAN

1 The circular in-line centrifugal fan shall be from the select range of **HOWDIN DONKIN, WOODS, VENTAXIA, PENN , ELTA or SYSTEMAIR FANS.**

2 Fan must be suitable to operate against moderate pressures.

3 The all metal casing shall be made from robust steel finished in high resist epoxy paint.

4 Impellers shall be single inlet backward curved type, quiet running, backward bladed centrifugal impellers.

5 Highly efficient, maintenance free external rotor motors shall be used, matched to the aerodynamic performance of the impeller. These shall be waterproofed to IP44 and suitable for speed control and working temperatures of up to +50°C. Electrical connection shall be provided by an 1P54 terminal box fitted onto the unit casing. The casing to be manufactured from galvanised sheet steel.

6 Highly efficient, light weight motors shall be provided, these will have sealed for life, maintenance free heavy duty ball bearings.

7 All units are to be designed and manufactured with procedures as defined in BS EN ISO 9001:2000. EEC directives shall be met.

8 Standard accessories must include speed controllers, fast clamps (galvanised sheet steel with neoprene foam linings), cylindrical in line attenuators and flexible connectors, and mounting brackets.

9 The inner lining of the sound attenuator to be pre-gavlanised, perforated mild steel that encloses mineral fibre sound absorbing material with glass facing tissue. Sound attenuator casing is manufactured from galvanised mild steel with one piece spun ends.

10 Fan units are to be tested to ISO 5801:1997 (airside performance) and BS 848 pt 2:1985 (sound performance).

5.16. IN-LINE RECTANGULAR DUCT CENTRIFUGAL FAN

1 The Hideaway in-line duct centrifugal single fan shall be from the Select range of **DONKIN, ELTA, SYSTEMAIR.**

2 Housings are to be manufactured from prime quality 0.9 or 1.2mm thick galvanised steel with circular spigots at both ends to suit ISO standard spiral ducting from 100mm to 315mm.

3 Casing is to be lined on the inlet side with 25mm high density, non toxic, flame retardant acoustic lining in compliance with BS476 Parts 6 and 7.

4 Access to the fan and motor is to be via an easily removable panel sealed using non hygroscopic neoprene and all fixings are to be non rusting.

5 Two M20 cable entry points are to be supplied one on either side of the casing.

6 Fans are to be single inlet, single width backward curved centrifugal type, directly driven by an energy efficient external rotor motor balanced in accordance with VDI 2060 class 02.5. Motor enclosure is to be lP44.

7 Motors are to be totally enclosed, air stream cooled

8 All units are to be suitable for working temperatures of up to +50°C.

9 Speed controllers and fast clamps must be included, and mounting brackets.

10 All units are to be designed and manufactured with procedures as defined in BS EN ISO 9001:2000. EEC directives shall be met.

11 Fans are to be tested to ISO 5801:1997 (airside performance) and BS 848 pt 2:1 985 (sound performance).

5.17. PACKAGED AIR CONDITIONING UNITS - AIR COOLED AND EVAPORATIVE CONDENSER COOLED

1 The packaged air conditioning units shall be suitable in all respects for outdoor location and shall be equal to **Daikin**, **Carrier, Viking, Ecoaire, Clivet** Roof Mounted Packaged Air Conditioners .

2 Units shall comprise of the following components all housed within or forming part of, their cabinet:

- Refrigeration Compressors
- Air Cooled Condensing coils
- Condenser Fans and Motors
- Refrigeration pipework and controls
- Refrigerant gas charge
- Direct Expansion Cooling coils
- Centrifugal Supply Air Fans with Motor and Belt Drive
- Electric Heater Elements
- Cleanable air filters
- Mixing plenum with Economy Cycle Dampers
- Electric Switchpanel
- Internal electrical wiring.

3 Unit casings shall be constructed of not less than 1,2mm thick mild steel panels suitably braced and framed so as to prevent drumming whilst at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic/thermal liner" or equivalent non-combustible material, such insulation being adequately secured to the internal surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer. Must be fitted with a 1,2 mm thick stainless steel condensate pan so sized and located to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.

4 Tenderers are to note that the unit casing specification above is the minimum required and that preference will be given to units having double skin panel construction. Further, preference will be given to units having an outer skin of anodised aluminium or be of fibreglass construction. Coastal unit casings shall be of

suitable corrosion resistant construction throughout and in general in accordance with the above.

5 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type direct driven by integral suction gas cooled squirrel cage motors at a rotational speed not exceeding 1500 r.p.m. The compressor shall be complete with positive displacement reversible force-feed lubrication systems, have low oil pressure protection and contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary.

6 Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

7 REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.

8 Condenser coils shall consist of copper tubes with mechanically bonded aluminium or copper plate fins, all housed in a robust galvanised steel frame and protected with a suitable galvanised wire mesh screen. Suitable space shall be provided at the coil ends in order that tube bends be easily accessible in the event of possible refrigerant leaks. For coastal regions the coils are to be treated with Coreum, Blygold or similar corrosion inhibitors.

9 Condenser fans shall be of the slow-running propeller type direct driven by squirrel cage electric motors. The units shall be provided with a minimum of two propeller fans which shall be arranged for preferably vertical discharge through suitable weatherproofed protective wire guards. The fan and motor bearings shall be of the permanently lubricated sealed type and the motor shall be resiliently mounted so as not to transmit vibrations to the unit casing.

10 Condenser air intake and discharge arrangements shall be such that no short-circuited discharge air can be drawn back into the air intake.

11 Refrigeration pipework shall be carried out in seamless refrigeration quality copper tubing, uitable provision being made that the piping is not subjected to any stresses by vibration from the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines. The systems shall be factory charged with Refrigerant 134A, R407C or R410A with zero ozone depletion potential, unless otherwise specified in Detailed Technical Specification

12 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side and an oil pressure switch with manual reset. Provision shall be made for pressure relief of the high side refrigerant piping in accordance with government regulations. Provision shall also be made for cycling the condenser fans so that the units may be capable of operating down to an ambient temperature of 10 °C db.

13 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits and shall comprise of copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge galvanised steel casing and fitted with a 1,2mm thick stainless steel condensate pan so sized and located to prevent

entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.

14 Cooling coil sizes shall be selected so that the face velocity does not exceed 2.5 m/s and a maximum of 12 fins per 25.4mm (fpi)

15 Supply air fans shall be of double inlet forward or backward curved centrifugal type with impellers running in sealed , permanently lubricated ball-bearing plummer blocks located in the suction eye of each side of each fan. Fan impellers shall be statically and dynamically balanced and run well below critical speed. Fan assemblies shall be so mounted within the packaged air conditioning unit that they do not transmit any vibration. Where units having more than one fan are offered, a common motor shall drive these fans.

16 Tenderers are to note that the supply air fan specification above is the minimum required and that preference will be given to units having a single backward curved centrifugal fan mounted on anti-vibration mounts and complete with a ventilated removable guard on the V-belt drive.

17 Supply air fan motors shall be three phase squirrel cage type rated not less that 25% above the power input absorbed by the fans and run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of a V-belt drive having not less than two V-belts. The V-belts are to be covered by a suitable removable guard.

18 Heater elements shall be of factory-bent incoloy type, rated for still air and fitted into the unit in such a manner as to ensure full airflow over each element. The elements are to have suitable corrosion protection for coastal regions.

19 The heater elements shall be fitted into a with-drawable fabricated galvanised channel frame. The side on which the terminals are located shall be fitted with a terminal base of sufficient size to contain all necessary electrical wiring, the terminal box being fitted with a removable weather proofed cover so fastened that no screw shall project into the actual terminal box.

20 The electrical wiring within the terminal box shall be affected in insulated wiring capable of withstanding the temperatures encountered without breakdown of the insulation.

21 Duct or unit mounted electric heater banks are to be earthed as required by local standards.

22 Air filters shall be minimum 50mm thick high performance washable pleated panel type housed in adequate holding frames and fitted with gaskets to ensure a positive airtight seal around them.

23 The filter media shall be a random layed, non-woven, synthetic, polyester fibre that has been saturation bonded. With an average arrestance of 90.0% on ASHRAE 52-76 test method

24 The media shall be pleated between two layers of 25mm x 25mm 22 gge coated wire mesh. Both layers of wire must conform to the profile of the pleats. The pleat shall be evenly spaced, must not touch one another and shall be open both back & front to allow maximum dust holding and ease of cleaning.

25 The filter frame shall not be thinner than 26gge (0,5mm) galvanised mild steel.

26 The filter cartridge shall be sealed into the enclosing frame by means of a mediapack and frame.

27 The return air and fresh air mixing plenum shall be factory installed and shall be of similar construction to the rest of the cabinet. The mixing plenum shall be complete with return air and maximum fresh air volume control dampers equal to those specified later herein.

28 Because of the potential use of an economy cycle and the resultant possible low on coil dry bulb temperature in the intermediate season the compressors shall be protected by low limit thermostats positioned in the mixing plenum and set to prevent the compressors from operating at a mixed temperature below 18 °C.

29 A weatherproof electrical switchpanel shall be incorporated to form part of the unit and shall house all the necessary switchgear and controls required to operate the various components within the units. The switchpanel shall comply with best modern practice and incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level (which is to be obtained from the Electrical Engineer). In addition phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be fully interlocked so that cooling and heating cannot operate simultaneously and so that the compressors cannot operate unless the condenser fans and supply air fans are operational. A run down timer shall be incorporated so that the supply air fans shall continue to run for three minutes after the unit is switched off. The switchpanels shall be fully labelled with engraved black ivorine labels having 6mm high white lettering. The labels shall be rivetted to chassis plates to identify all switchgear, relays, instruments and controls inside the switchpanel.

30 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type porcelain insulators. All exposed current carrying parts must be fully insulated in P.V.C. tape of the colours mentioned above. Every wire inside and outside the switchpanel shall be fitted with ferrules and labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.

31 The RTPU shall be of reverse cycle type with dry-bulb based economy cycle feature and situated on an open plant room slab adjacent to the store. Conditioned air will be supplied to diffusers and returned through grilles via rectangular externally insulated galvanized sheet metal ducting. The ducting supplying and returning conditioned air into and from the spaces will run at high level under the roof trusses. Air will be returned via fixed blade return air grilles and ducting connected to the unit. Two (2)-off averaging sensors per unit will be mounted in the space and will control the unit. A remote panel for the plant will be situated in the Managers office as per the detailed drawings and electrical schematics. Flexible ducting from ducting to diffusers shall not exceed 1500 in length. Air will be returned via fixed blade return air grilles and externally insulated sheet metal ducting connected to the grilles and the package unit. All ducting on the outside of the building will be internally insulated or as per WW Spec.

32 **RTPU** shall be standard products of reputable manufacture complete either with digital scroll unloading, inverter drive scroll compressors suitable to operate under

unloaded cooling operation with econo-cycle air-on cooling coil conditions as low as 18 degree C. Also linked to CO2 sensor on the return air.

33 Important: **RTPU shall have three refrigeration circuits and three compressors with interlaced evaporator coils** and with condenser airflow arrangement such that air will not bypass the inactive coil with only one refrigeration circuit in operation.

34 **RTPU** shall be complete with economy cycle operation controls, but 100% outdoor air damper will be supplied by the HVAC sub-contractor for installation on the return air ducting located as shown on the drawings.

35 Controls shall allow for extended control module to be wall mounted inside the store from where the **RTPU** shall be switched automatically on/off with manual over-ride and a facility whereby the controlled set-point can be adjusted.

36 Reverse cycle heating shall have minimum heating capacity equal to 50% of the specified cooling capacity for operation under 7 degree C ambient condition.

37 **RTPU** offered shall comply with the following:

- Unit MCP to include for fire interlock
- Filters shall be 50mm pleated with maximum approach velocity of 2.4 m/s to EU4 standard
- Temporary filter media to protect the unit during commissioning/construction
- Refrigerant shall be either R-407 or R-410a
- Head pressure control shall be with fan speed control
- Evaporator coil drain pan shall be either St St or Aluminium
- Condenser coils shall be protected against hail damage
- One refrigeration circuit per unit shall be provided with an electronic Xpansion valve
- Unit casing shall be double skin sandwhich construction with a minimum 40mm foam insulation
- Units shall be mounted on TICO pads on concrete plinths
- Supply air fan outlet velocity shall not exceed 12 m/s
- On-evaporator coil velocity shall not exceed 2.4 m/s
- On-condenser coil velocity shall not exceed 2.8 m/s
- Units shall be selected at altitude 1700m with on-coil and off-coil conditions as per equipment schedule and at provisional external statics as listed. Final external statics shall be determined by the HVAC contractor once actual shop distribution systems have been finalised. Calculations shall be submitted to the Engineer for approval.
- Units shall include Hi/Lo refrigerant pressure cut-out protection
- Units shall include condenser/evaporator fan thermal overload protection
- Units shall include compressor current and thermal overload protection
- Units shall include de-ice protection without cold

ALL UNITS TO BE SUPPLIED AS PER THE FOLLWING

Construction

Mesh/Hail guards around the condenser sections and fans

40 mm Thick Insulation

All units to be supplied complete with disposable filter media for blow out during construction

All units to be provided with bubble wrap plastic cover c/w corner protectors and straps to protect unit during construction.

Refrigeration

Defrost cycle control

Pressure Guages (High + Low)

Moisture Sight Glass Indicator

Suction and discharge service valves

Electrical

All units to be able to accept fire interlock and shut down in the event of a fire

Circuit breaker for each compressor

Circuit breaker for each condenser fan motor

Circuit breaker for supply air fan motor

Main power circuit breaker for whole unit with door isolator

External overload for each compressor motor

Phase reversal relay

Units to be supplied complete with advanced Johnson/Carel Controller and Extended Remote Panel in Managers Office as indicated on drawing. (See note Note 7 on Packaged unit Equipment Schedule)

- Unit MCP to include for fire interlock

- Filters shall be 50mm pleated with maximum approach velocity of 2.4 m/s to EU4 standard

- Temporary filter media to protect the unit during commissioning/construction

- Refrigerant shall be either R-407 or R-410a

- Head pressure control shall be with fan speed control

- Evaporator coil drain pan shall be either St St or Aluminium

- Condenser coils shall be protected against hail damage

- One refrigeration circuit per unit shall be provided with an electronic Xpansion valve

- Unit casing shall be double skin sandwhich construction with a minimum 40mm foam

insulation

- Units shall be mounted on TICO pads on concrete plinths

- Supply air fan outlet velocity shall not exceed 12 m/s

- On-evaporator coil velocity shall not exceed 2.4 m/s

- On-condenser coil velocity shall not exceed 2.8 m/s

- Units shall be selected at altitude 1700m with on-coil and off-coil conditions as per equipment schedule and at provisional external statics as listed. Final external statics shall be determined by the HVAC contractor once actual shop distribution systems have been finalised. Calculations shall be submitted to the Engineer for approval.

- Units shall include Hi/Lo refrigerant pressure cut-out protection

- Units shall include condenser/evaporator fan thermal overload protection

- Units shall include compressor current and thermal overload protection

Units shall include de-ice protection without cold

5.18. PACKAGED AIR CONDITIONING UNITS - WATER COOLED

1 The water cooled packaged air conditioning units shall comprise the following components all housed within, or forming part of, their steel cabinet:-

- Refrigeration Compressors
- Water Cooled Condenser
- Refrigeration pipework and Controls
- Refrigerant Gas Charge
- Direct Expansion Cooling Coil
- Centrifugal supply air fans with Motor and Belt Drive
- Cleanable Air Filters
- Electrical Switchpanels
- Internal Electrical Wiring

2 Unit casings shall be constructed of not less than 1,2mm thick mild steel panels suitable braced and framed so as to prevent drumming while at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. The casing panels shall be internally lined with "sonic liner" or equivalent non-combustible material, such insulation being adequately secured to the internals surfaces with non-combustible adhesive and mechanical fasteners. All mild steel casing panels and frame work shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

3 For coastal regions the unit casings shall be of suitable corrosion resistant construction throughout and generally in accordance with the above. *REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.*

4 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type direct driven by integral suction gas cooled squirrel cage motors at a rotational speed not exceeding 1500 r.p.m. The compressors shall be complete with positive displacement reversible force-feed lubrication systems, have low oil pressure protection and contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary. Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

5 Coastal unit casings shall be of galvanised construction throughout and generally in accordance with the above.

6 Each compressor shall be provided with its own tube in tube, shell and coil, or shell and tube water-cooled condenser and shall incorporate a pressure relief device to comply with Government Regulations. All tubing within the condensers shall be of copper.

7 Refrigeration pipework shall be carried out in seamless refrigeration quality tubing, suitable provision being made that the piping is not subjected to any stresses by vibration from the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines. The system shall be factory charged with Refrigerant 134A, R407C or R410A with zero ozone depletion potential, unless otherwise specified in Detailed Technical Specification.

8 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side and an oil pressure switch with manual reset. Units shall incorporate timing devices to delay starting of compressors in order that refrigerant pressures may first balance between starting and stopping of the compressors.

9 Direct expansion cooling coils shall consist of at least two separate refrigerant circuits and shall comprise copper tubes with mechanically bonded aluminium fins. The coils shall be encased in a heavy gauge galvanised steel casing and fitted with a 1,2mm thick stainless steel condensate pan so sized and located to prevent entrainment of moisture into the air stream, whilst also ensuring positive drainage of condensate.

10 Cooling coil sizes shall be selected so that the face velocity does not exceed 2,5 m/s.

11 Supply air fans shall be of double inlet forward or backward curved centrifugal type with impellers running in sealed permanently lubricated ball-bearing plummer blocks located in the suction eye of each side of each fan. Fan impellers shall be statically and dynamically balanced and run well below critical speed. Fan assemblies shall be so mounted within the packaged air conditioning unit that they do not transmit any vibration. Where units having more than one fan are offered, these shall all be driven by a common motor.

12 Supply air fan motors shall be three phase squirrel cage type rated not less than 25% above the power input absorbed by the fans and run at a rotational speed not exceeding 1500 r.p.m. The motor shall drive the fans by means of a V-belt drive having not less than two V-belts with suitable removable belt guards.

13 Air filters shall be minimum 50mm thick high performance washable pleated panel type housed in adequate holding frames and fitted with gaskets to ensure a positive airtight seal around them.

14 An electrical switchpanel shall be incorporated to form part of the unit and shall house all the necessary switchgear and controls required to operate the various components within the unit. The switchpanel shall comply with the best modern practice and incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level. In addition, phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be fully interlocked so that cooling and heating cannot operate simultaneously or so that the compressors cannot operate unless the condenser water pump and the supply air fans are operational. A run down timer shall be incorporated so that the supply air fans shall continue to run for three minutes after the unit is switched off. The switchpanels shall be fully labelled with engraved black ivorine labels having 6mm high white lettering. The labels shall be rivetted to chasses plates to identify all switchgear, relays, instruments and controls inside the switchpanel.

15 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type porcelain insulators. All exposed current carrying parts must be fully insulated in P.V.C. tape of the colours mentioned above. Every wire inside and outside the switchpanel shall be fitted with ferrules and labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.

16 Water-Cooled Packaged Units shall be equivalent to the make specified on the layout drawings or in the Detailed Technial Specification herein.

17 All equipment stored or installed on site shall be adequately protected at all times, until the final overall acceptance of the entire installation by the engineer.

5.19. PROPELLER FANS

1 Propeller fans shall be of the size and type as indicated on the Drawings and shall be capable of the duties specified in the Detailed Technical Specification hereof.

2 Propeller fans shall be of the direct connected, motor-driven type **HOWDIN DONKIN, WOODS, VENTAXIA, PENN & ELTA** manufacture. Wheels shall have steel or aluminium blades with heavy hubs. The fans shall be quiet in operation and shall be dynamically balanced.

3 Mounting rings or plates shall be cast or die formed to smooth curves where the air enters the wheels. Mounting plates shall be heavy enough to prevent distortion and shall be turned up` at all edges or braced with steel angles.

4 Propeller fans mounted below the ceiling shall be provided with wire mesh guards.

5 Where indicated on the Drawings, propellers fans shall be mounted within correctly proportioned fan chambers suitable for connecting to ducting. The fan chambers

shall be designed to allow the required space for radial air flow into and from the impeller tips and shall be fitted with diaphragm plates for mounting the fans, suitable fixing flanges at both ends, external terminal boxes and an access door for inspection and maintenance of the fan motors. The fan chamber casing shall be manufactured of 1,2mm thick galvanised sheet steel.

6 Exhaust fans to be installed through walls shall be **XPELAIR** type WX built-in wall fans having an ivory coloured finish and complete with a back-draught shutter to open and close as the fan is switched on and off.

7 Exhaust fans to be installed through windows shall be **XPELAIR** type GX having an ivory coloured finish, and shall be complete with automatic shutters that shall close off the fan openings when the fans are not in operation. The fans shall be fitted through the windows into circular openings in the glazing to be provided by the Principal Contractor.

8 ingle phase fans shall be wired in neatly affixed, suitably rated, three core white cab tyre flex to white plug tops, to be plugged into adjacent switch plugs to be provided by others in the positions indicated on the Drawings.

9 All ferrous parts of fan components shall be corrosion free and for coastal regions will be suitably protected against corrosion.

5.19. REFRIGERANT CHARGE

1 Refrigerant pipework systems shall be charged with refrigerant after evacuation and testing for leaks as outlined below:-

2 Complete refrigeration circuits shall be tested by means of dry Nitrogen to a pressure of at least 50% above working pressure. With the system under the pressure of the Nitrogen, brush all possible points of leakage with a solution of soap and water to which a few drops of Glycerine have been added. All soldered joints shall be tapped with a hammer to break possible flux seals. Any leaks which may be found by bubbling of the soapy water should be made good after the Nitrogen has first been released. When a leaking joint is detected, the fitting shall be taken out, cleaned and resoldered into the pipework again.

3 Systems should next be charged with Refrigerant to a minimum pressure of 200 kPa and then brought to a pressure of at least 50% above working pressure with dry Nitrogen. A **"HALIDE"** or Electronic leak detector shall at this stage be used to detect any further leaks.

4 Systems found to be free of leaks shall be allowed to remain under pressure for a 24 hour period. If no pressure drop is observed after this period, taking into account ambient air temperatures, the Nitrogen mixture shall be discharged to atmosphere.

5 The system shall then be evacuated by means of a suitable vacuum pump to a vacuum of 2,5mm of Mercury, allowed to stand for 12 hours and, if no pressure rise has occurred , shall be charged with refrigerant via the charging valve.

6 No refrigeration gas shall be discharged to atmosphere. **Anyone found doing so will be criminally charged & prosecuted accordingly**

7 THE HVAC CONTRACTOR MUST COMPLY TO SPECIFIC PROCEDURE FOR REFRIGERANT CHARGE IN THE HVAC PROJECT SPECIFICATION. THE

CONTRACTOR MUST STRICTLY COMPLY TO THE *VARIABLE REFRIGERANT SYSTEM (VRS*) SUPPLIER / SPECIALIST MANUALS IN TERMS OF REFRIGERANT CHARGE.

5.20. REFRIGERATION CONDENSING UNITS - AIR COOLED (NON VARIABLE REFRIGERANT FLOW SYSTEMS)

1 Air cooled refrigeration condensing units shall be suitable in all respects for outdoor location and shall comprise the following components housed within, or forming part of, its cabinet:-

- Refrigeration Compressors
- Air Cooled Condensing Coils
- Condenser Fans and Motors
- Refrigeration pipework and controls
- Refrigerant gas charge
- Electric switchpanel
- Internal electrical wiring.

2 Unit casing shall be constructed of not less than 1,2 mm thick mild steel panels suitably braced and framed so as to prevent drumming whilst at the same time being arranged in easily removable panels to facilitate access to any portion of the internal components. Casing panels shall be attached to a sub-frame of welded mild steel sections, which framework shall also hold all internal equipment in position. All mild steel casing panels and framework shall be thoroughly degreased and then painted with a suitable rustproofing primer prior to the application of two finishing coats of good quality enamel or lacquer in the standard colour of the manufacturer.

3 *Coastal unit* casings shall be of suitable corrosion resistant construction throughout and generally in accordance with the above. *REFER TO CORROSION PROTECTION FOR COASTAL AND CORROSIVE AREAS IN A SEPARATE CHAPTER INCLUDED.*

4 Units shall contain a minimum of two refrigeration compressors. These shall be of the hermetic or the accessible hermetic type direct driven by integral suction gas cooled squirrel cage type motors at a rotational speed not exceeding 1500 r.p.m. The compressors shall be complete with positive displacement reversible force-feed lubrication systems, have low oil pressure protection and contain crankcase oil heaters to ensure boil-off of dissolved refrigerant from lubricating oil when the compressors are stationary. Each compressor shall have at least one stage of capacity modulation other than full load and shall be arranged to start unloaded.

5 Condenser coils shall consist of copper tubes with mechanically bonded aluminium plate fins, all housed in a robust galvanised steel frame and protected with a suitable galvanised wire mesh screen. Suitable space shall be provided at the coil ends in order that tube bends be easily accessible in the event of possible refrigerant leaks.

6 Condenser coils installed under *coastal conditions* shall consist of copper tubes with mechanically bonded copper plate fins, all housed in a robust stainless steel frame and protected with a suitable stainless steel wire mesh screen. The coils are to be treated with Coreum, Blygold or similar corrosion inhibitors.

7 Condenser fans shall be of the slow-running propeller type direct driven by squirrel cage electric motors. The units shall be provided with a minimum of two propeller fans which shall be arranged for preferably vertical discharge through suitable weatherproofed protective wire guards. The fan and motor bearings shall be of the permanently lubricated sealed type and the motor shall be resiliently mounted so as not to transmit vibrations to the unit casing.

8 Condenser air intake and discharge arrangements shall be such that no short-circuited discharge air can be drawn back into the air intake.

9 Refrigeration pipework shall be carried out in seamless refrigeration quality copper tubing, suitable provision being made that the piping is not subjected to any stresses by vibration from the compressors. The refrigeration system shall be split into at least two stages on the liquid side for adequate capacity control. Refrigerant circuits shall incorporate replaceable type filter-driers, sight glasses, thermostatic expansion valves and vapour proof insulation on the suction lines.

10 Automatic safety controls within the unit shall include a dual pressure switch with manual reset on the high pressure side and an oil pressure switch with manual reset. Provision shall be made for pressure relief on the high side refrigerant piping in accordance with government regulations. Provision shall also be made for cycling the condenser fans so that the unit may be capable of operating down to an ambient temperature of 10 °C db.

11 A weatherproof electrical switchpanel shall be incorporated to form part of the unit and shall house all the necessary switchgear and controls required to operate the various components within the unit. The switchpanel shall comply with best modern practice and incorporate all necessary protection against overload or short-circuit. The switchpanel shall be fitted with a suitably sized main isolator backed up by High Rupturing Capacity fuses with a minimum capacity to suit the system fault level. In addition phase failure relays shall be incorporated to protect against low voltage or phase failure. The switchgear shall be interlocked so that the compressors cannot operate unless the condenser fans are operational. The switchpanel shall be fully labelled with engraved black ivorine labels having 6mm high white lettering. The labels shall be rivetted to chassis plates to identify all switchgear, relays, instruments and controls inside the switchpanel.

12 Wiring within the switchpanel and the unit shall comply with wiring regulations as relevant and shall be neatly grouped in horizontal and vertical runs in P.V.C. trunking. All wiring shall be colour-coded in the colours red, yellow and blue for the relevant phases and black for neutral, the busbars being similarly marked. Busbars shall be copper of adequate cross sectional area, suitably spaced and mounted on stand-off type black porcelain insulators. All exposed current carrying parts must be fully insulated in P.V.C. tape of the colours mentioned above. Every wire inside and outside the switchpanel shall be fitted with ferrules and labelled with identical numbers at both ends. All outgoing leads shall be connected to a clearly marked terminal strip.

13 Air cooled refrigeration condensing units shall be selected to match the associated air handling unit and be equivalent to the make specified on the layout drawings or in the Detailed Technical Specification section herein. Piping external to the unit shall run in suitably treated trunking that is covered from direct solar radiation. Pipework insulation to be **Thermobreak, Armaflex or Idoflex.**

5.21. VARIABLE FREQUENCY DRIVES

1 Variable Frequency Drives shall be of Make DANFOSS, Model FC102.

2 Variable Frequency Drives shall Feature the following IP Ratings;-

i. Indoor Minimum IP21

ii. Outdoor Minimum IP55

3 Variable Frequency Drives kW selection must take into account motor power factor.

4 Panels Housing Variable Frequency Drives shall be force ventilated, complete with changeable dust filter and meet ventilation requirements as outlined by Danfoss.

5 Variable Frequency Drives shall feature EMI / RFI and DC Filters.

6 Variable Frequency Drives shall not be installed in same MCP or within 1m of any control or electronic equipment. (Refer VLT HVAC Design Guide)

7 Variable Frequency Drives shall be MODbus RTU communication ready.

8 Any VSD installed outside shall have a 1.2mm sheetmetal roof (on a steel frame size 900mm wide x 900mm long and 250mm) above the VSD. This is to ensure that rain water or U V rays do not enter or damage the VSD

5.22. VARIABLE REFRIGERANT SYSTEM (VRS / VRV / VRF)

1 IMPORTANT NOTE: HVAC TENDERER MUST :-

- COST ALL THE EQUIPMENT IN THE EQUIPMENT CONTROL SCHEDULES
- COMPLETE ALL SCHEDULES AFTER TENDER AND SUBMITTED TO THE ENGINEER.
- All performance data is to be given at actual site operating conditions.
- **Any deviation from the specification relating to equipment included in the main offer is to be specifically listed in tender offer, otherwise we deem all the items listed to be included.**

2 Equipment must be DAIKIN VRV III / IV or MITSUBISHI ELECTRIC CITY MULTI R2.

3 The system is a low energy air-cooled direct expansion Variable Refrigerant System (VRS) with Inverter Heat Pump or Heat Recovery.

4 The VRS system would be a multiple in- and outdoor unit system and can heat Recovery version must simultaneously cool and heat at the same time from the same system.

5 The outdoor compressor units would normally be located on the roof of the building, and refrigerant would be reticulated to indoor units (located on levels below) by means of a refrigerant pipe system.

6 The outdoor units would incorporate inverter hermetically sealed scroll compressors operating on refrigerant R410a.

7 An efficient brushless DC motor will be used to drive the compressor and will be inverter controlled. A DC motor will drive the condenser fan.

8 Hide-away indoor units would be installed in the ceiling on each floor or as show on drawings.

9 Each indoor unit would contain the necessary washable removable (clip in/out) filters and filter box, fire resistant insulation, coil and 3-speed supply air fan.

10 Each indoor unit shall be provided with a supply air diffuser, a formed insulated condensate drain pan and hose (indoor units are to be supplied with condensate drain pump kit).

11 The condensate drip tray below the fan coil unit shall be connected to a condensate drain provided by the plumber in the ceiling void at the fan coil unit.

12 If close to a wash hand basin, the insulated condensate drain shall be connected on the incoming side of a wash hand basin trap or drain to prevent smells being distributed into the room via the fan coil unit.

13 All indoor units will have dedicated controllers with a 5m wire, controlling within a tolerance of 1.5ºC of the design temperature. Controllers will be wired to the indoor units. The controller to enable on/off switching, fan speed control and temperature selection. The controller screen shall be backlit, and the text shall be large enough to read. All the buttons on the controller shall be soft touch.

14 Each indoor unit will be connected to a group controller, where the set points can be adjusted, to enable on/off switching, fan speed control and temperature selection. The controller will be located in a control room or a managers / supervisor office (final position will be advised by engineer).

15 If cooling or heating is required in a room after hours, only a fraction of the plant needs to operate, and not the entire plant.

16 The entire air-conditioning and ventilation systems must not exceed a power consumption of 45W/m2 or less.

17 The outdoor units and refrigerant controllers will be linked to the group controller. The controller(s) would be equal to Mitsubishi G-50A (with display) or equal and approved. The tender price must include all conduiting and wire, testing and commissioning and detailed specialists designs. These conduits would have to be built in during building operations. The cost of all software (if any) and programming is to be included in the tender price. Upon interruption and restoration of power, the controller shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, implement special start-up strategies as required.

18 The controller is capable of monitoring and displaying the following information individually for 50 indoor fan coil units: - On/Off, Operating mode, Set point, Return air temperature, Fan speed, Louver position, Timer settings, Test run, Fault diagnosis,

19 The following local remote controller functions can be lockable from the controller: Mode, Set point, Fan speed, A 7-day schedule is available as standard from the remote controller. Peak load shedding of HVAC system, Advanced tenant management of HVAC system, Power Proportional Distribution of HVAC system Off

site remote control of all buildings on this site, Fire emergency stop control of HVAC system, Interlocking control of HVAC system, Indication filter replacement of HVAC system, Web access function, Operation history of HVAC system, Eco module of HVAC system.

20 The G-50A is fitted with a 10 Base T Ethernet port as standard. This enables the G-50A to be connected directly to a computer via a cross over cable or to a Local Area Network (LAN) via a hub / router. It is then possible to control and monitor all the functionality listed above. This is achieved through HTML pages and JAVA script contained within the G-50A. The computer downloads the WebPages in JAVA script via a standard browser (Internet Explorer IE 5 or IE6). Information is displayed in a basic graphic format with textural based fault diagnosis.

21 With City Multi Y-series outdoor units, the G-50A is capable to automatically change the mode of the outdoor (Automatic change over) using 2 options: Automatic (voting), Master unit (any units on the network may be set-up as the master). This will enable the 'master' unit to force a change in the control mode (heating/cooling) of the outdoor unit.

22 Refrigerant pipe sizes, depending on the equipment make selected, to be accurately calculated by manufacturer (VRS specialist) and included in tender costs, complete with installation costs.

23 The HVAC contractor to comply with refrigerant piping lengths, piping size, joint and header selections strictly in accordance to the VRS manufacturers requirements.

24 Refrigerant pipe for the VRS shall be made of phosphorous deoxidized copper using two types :

- Type-O : Soft copper pipe (annealed copper pipe), can be easily bent with human's hand.
- Type-1/2H pipe : Hard copper pipe (Straight pipe), being stronger than Type-O pipe of the same radical thickness. Maximum allowed tensile stress is 61N/mm2. The 0.2% proof strength shall be 61N/mm2.

25 The maximum operation pressure of R410a air conditioner is 4.30 MPa. The refrigerant piping should ensure the safety under the maximum operation pressure. We recommend pipe size as Table below. Pipes of radical thickness 0.7mm or less shall not be used.

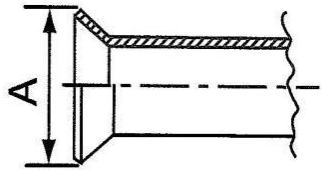
Table : Copper pipe size and radial thickness for R41Oa VRS

Dia Size (mm)	Dia Size (inch)	Radial thickness (mm)	Pipe type
06.35	1/4"	0.8	Type-O
09.52	3/8"	0.8	Type-O
12.7	1/2"	0.8	Type-O
15.88	5/8"	1.0	Type-O

19.05	3/4”	1.2	Type-O
19.05	3/4”	1.0	Type-1/2H
22.2	7/8”	1.0	Type-1/2H
25.4	1’’	1.0	Type-1/2H
28.58	1-1/8”	1.0	Type-1/2H
31.75	1-1/4”	1.1	Type-1/2H
34.93	1-3/8”	1.2	Type-1/2H
41.3	1-5/8	1.43	Type-1/2H

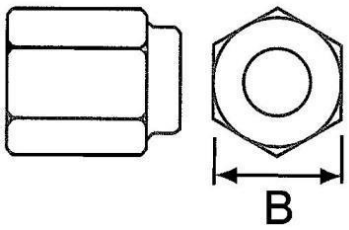
26 Due to the relative higher operation pressure of R410a compared to R22, the flare connection should follow dimensions mentioned below so as to achieve adequate resistance.

Flare pipe



Pipe size	B (For R410a)
dia 6.35 [1/4]	9.1
dia 9.52 [3/8”]	13.2
dia 12.70 [1/2”]	16.6
dia 15.88 [5/8”]	19.7
dia 19.05 [3/4”]	24.0

Flare nut



Pipe size	B (For R410a)
06.35 [1/4”]	17.0
09.52 [3/8”]	22.0
015.88 [5/8”]	29.0
012.70 [1/2”]	26.0
019.05 [3/4”]	36.0

27 Refrigerant charging calculation :Original charge of refrigerant and the maximum total charge:- At factory shipment, refrigerant is charged in the outdoor unit. When extending the piping in the field, additional charge of refrigerant is needed and to be costed at tender by HVAC tenderer (contractor) in accordance to the manufacturers (VRS specialist) calculations. The manufacturer maximum allowable total charge in the air conditioner system should not be exceeded.

28 Caution for refrigerant leakage R410A :The HVAC Contractor and/or air conditioning system specialist shall ensure safety against refrigerant leakage according to local regulations or standards and must comply fully to this clause. The following standard may be applicable if no local regulation or standard is available.

29 Refrigerant property:

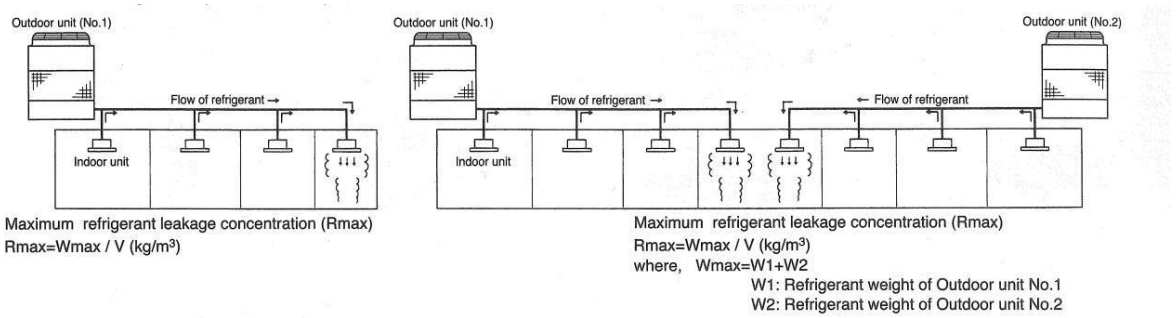
- R410a refrigerant is harmless and incombustible. R410a is heavier than indoor air in density. Leakage of the refrigerant in a room has possibility to lead to a hypoxia situation. Therefore, the Critical concentration specified below shall not be exceeded even if the leakage happens.

- Critical concentration hereby is the refrigerant concentration in which no human body would be hurt if immediate measures can be taken when refrigerant leakage happens.
- Critical concentration of R410a: 0.30kg/m3 . (The weight of refrigeration gas per 1 m3 air conditioning space.) The Critical concentration is subject to IS05149, EN378-I.
- For the VRS, the concentration of refrigerant leaked should not have a chance to exceed the Critical concentration in any situation.
- Confirm the Critical concentration and take countermeasure :

30 The maximum refrigerant leakage concentration (Rmax) is defined as the result of the possible maximum refrigerant weight (Wmax) leaked into a room divided by its room capacity (V). It is referable to Fig. below. The refrigerant of Outdoor unit here includes its original charge and additional charge at the site.

31 The additional charge is calculated according to the refrigerant charging calculation of each kind of Outdoor unit, and shall not be over charged at the site. Procedure 1 - 3 tells how to confirm maximum refrigerant leakage concentration (Rmax) and how to take countermeasures against a possible leakage.

32 Figure below - The maximum, refrigerant leakage concentration



33 Procedure: 1. Find the room capacity (V), If a room having total opening area more than 0.15% of the floor area at a low position with another room/space, the two rooms/space are considered as one. The total space shall be added up. 2. Find the possible maximum leakage (Wmax) in the room. If a room has Indoor unit(s) from more than 1 Outdoor unit, add up the refrigerant of the Outdoor units. 3. Divide (Wmax) by (V) to get the maximum refrigerant leakage concentration (Rmax). 4. Find if there is any room in which the maximum refrigerant leakage concentration (Rmax) is over 0.30kg/m3. If no, then the VRS is safe against refrigerant leakage. If yes, following countermeasure is recommended to do at site.

34 Countermeasure: 1. Countermeasure 1: Let-out (making V bigger). Design an opening of more than 0.15% of the floor area at a low position of the wall to let out the refrigerant whenever leaked e.g. make the upper and lower seams of door big enough. 2. Countermeasure 2: Smaller total charge (making Wmax smaller) e.g. Avoid connecting more than 1 Outdoor unit to one room, e.g. Using smaller model size but more Outdoor units, e.g. Shorten the refrigerant piping as much as possible. 3. Countermeasure 3: Fresh air in from the ceiling (Ventilation) : As the density of the refrigerant is bigger than that of the air. Fresh air supply from the ceiling is better than air exhausting from the ceiling.

Fresh air supply solution refers to Fig. 2 to 4 below

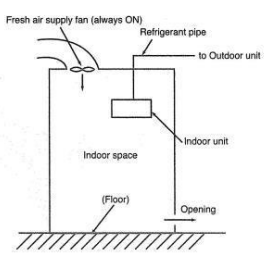


Fig. 2. Fresh air supply always ON

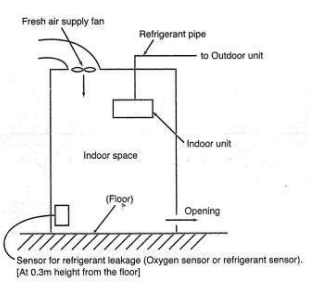


Fig. 3. Fresh air supply upon sensor action

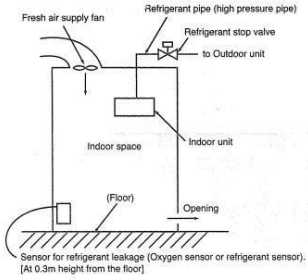


Fig. 4. Fresh air supply and refrigerant shut-off upon sensor action

35 Note 1. Countermeasure 3 should be done in a proper way in which the fresh air supply shall be on whenever the leakage happens. Note 2. In principle, the VRS manufacturers requires proper piping design, installation and air-tight testing after installation to avoid leakage happening.

36 In the area should earthquake happen, anti-vibration measures should be fully considered. The piping should consider the extension due to the temperature variation.All refrigerant piping and fittings shall be insulated in accordance with the HVAC General Technical Specification, to the VRS manufacturers' and the engineer's satisfaction.

37 All pipe supports / trays exposed to the weather shall be hot dip galvanized or constructed of other non-corrosive robust strong material.

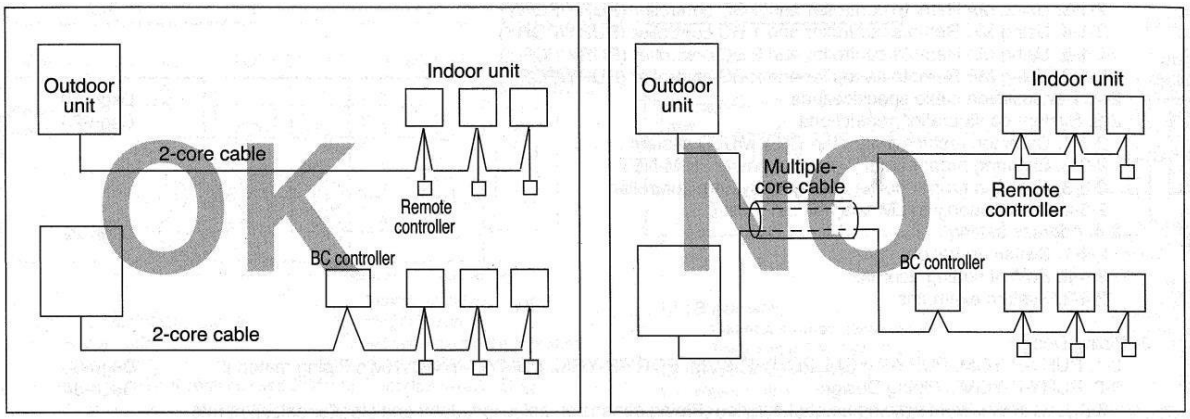
38 Refrigerant pipe installation

- During brazing of pipework, Nitrogen must flow thru the pipes putting it under positive pressure
- Must perform flushing and cleaning of pipes.
- Must perform air tightening test to prevent refrigerant leakage. Must perform vacuum drying to prevent moisture in refrigerant circuits.
- Must use correct and purpose made tools (e.g. copper tube cutter, no saw) when installing piping and connections.
- Must store pipes correctly (i.e. with seal plugs, store pipes on stand). Under no circumstances must dirt enter in pipes. Should dirt in pipes be the cause of system failure, the contractor is responsible for replacement of failed systems free of charge.
- Must ensure correct security is in place to prevent copper pipes theft (stored or installed). This is the HVAC contractor's responsibility and we will not accept any time or cost claims as result of copper pipe theft.
- Must install refnet according to supplier specification manual.

39 Transmission cable connections between indoor and outdoor units. The HVAC contractor to comply to the following: General cautions for transmission cable connections between indoor and outdoor units:

- Follow the ordinance of local authorities for the technical standard related to electrical equipment, wiring regulations, and guidance of each electric power company.
- Wiring for control (hereinafter referred to as transmission cable) shall be (100mm or more) apart from power source wiring so that it is not influenced by electric noise from power source wiring. (Do not insert transmission cable and power source wire in the same conduit.)
- Be sure to provide designated grounding work to outdoor unit.

- Give some allowance to wiring for electrical part box of indoor and outdoor units, because the box is sometimes removed at the time of service work.
- Never connect 380-415V or 220-240V power source to terminal block of transmission cable. If connected, electrical parts will be burnt out and it will be the contractor to repair at his cost.
- Use 2-core shield cable for transmission cable. If transmission cables of different systems are wired with the same multiple-core cable, the resultant poor transmitting and receiving will cause problems. Daisy chain cabling with 2 core 1,5mm² non-polarity shielded cable should be used.



40 ELECTRICAL SWITCHBOARDS AND WIRING:

- Electrical contractor to provide 380V 50Hz power (via cable)to:
- The DB board that feeds the VRS system, with a fire alarm relay
- The electrical contractor to provide Voltage and Surge protectors that are built into their upstream electrical boards, as a standard, which covers the incoming supply to our entire board.

41 HVAC contractor to provide:

- The DB board that feeds both the outdoor units and indoor units,
- Wiring from the board to the outdoor units and indoor units and BS boxes (or refrigerant flow control devices)
- Wiring and Isolators adjacent to each outdoor unit 380V 50Hz
- Wiring and Isolators adjacent to each indoor unit and BS boxes (or refrigerant flow control devices) 230V 50Hz
- The HVAC contractor to provide additional Voltage and Surge protectors in the DB board which covers the incoming supply to our entire VRS system.
- Wiring from the fan coil units to the isolator by HVAC contractor, as well as wiring to the F.C.U.'s. controls and temperature sensors and group controllers and outdoor units.

42 The VRS comprises of outdoor units, indoor units, refrigerant controllers, electronic controls, sensors, thermostats, wires, joints, headers and all this equipment must be from the same supplier.

43 The successful tender must provide a technician in the role as a supervisor for the duration of the project and maintenance period. This technician shall attend and succesfully complete a training course at the VRS manufacturer and obtain a

certificate for passing the course. The technician shall have detailed knowledge of the VRS installation, piping installation, commissioning procedures etc.

44 Storage strictly to supplier's recommendations.

45 Outdoor-, indoor- and refrigerant controller units to be microprocessor controlled utilizing R410a ozone friendly refrigerant.

46 Two system descriptions follow and contractor must comply to one of the options:

47 Option A: System Description for HEAT RECOVERY INVERTER VARIABLE REFRIGERANT FLOW SPECIFICATION **– 2 PIPE technology**

- Provide simultaneous heating and cooling via a process of heat recovery and re-direction of refrigerant. R410A refrigerant.
- For installation simplicity a maximum use of two refrigerant pipes only, one for gas line and one for liquid line is to be used.
- Heat Recovery refrigerant flow distribution boxes (BC Controllers) to provide redistribution of refrigerant to multiple units from one box, supplying refrigerant as required by the various evaporators (indoor units). Thus supplying simultaneous heating or cooling.
- Make minimum use of pipe work connections to reduce the possibility of leaks. Minimize the welding to reduce labour required.
- Systems must incorporate a continuous integrated oil recovery process taking only a few seconds. No oil recovery mode where the system switches off for a period is acceptable.
- System must continue to operate between changes of modes from cooling to heating and vice versa. The system must not switch off to make this change.
- Incorporation of a Night time quiet operation of 49dB on the condensers must be possible.
- Condensers heat exchangers have Anti-corrosion salt and acid rain protection and Blue Fin coating as a standard with Pre-coated galvanized metal casings. Powder coated
- Protection devices must include: High pressure protection: High pressure switch 4.15MPa (601 psi), Inverter circuit: Over-voltage and over-current protection for AC bus & Over-heat protection, Compressor/fan: Over-heat protection/Thermal switch, Condensers are to have maximum of two compressors per system. At least one of these is to be an inverter scroll hermetic compressor.
- The External Static Pressure of the condensers should be a minimum of 60Pa.
- Controllers must have option of automatic group control.
- Provide a system capable of diversity between 50-130% of condenser capacity. Select on **115%** if not specifically specified elsewhere.
- Variable refrigerant flow flash gas controlled by linear expansion valves and inverter compressors.
- Accumulator can store 80% of refrigerant when not required or in repair condition.
- Composition sensing circuit (CS Circuit) monitors the make up of the refrigerant
- BC Controllers: Galvanized metal casing, with copper refrigerant piping and liquid/gas separator. Two pipe simultaneous heating and cooling providing heat recovery with C.O.P of up to 7.5 when zones are mixed efficiently. HVAC contractor to ensure that a condensate drain point and 220V isolator is supplier adjacent to controllers. Must have PC board fuse and be complete with fixing brackets.

- The system must be able to perform a refrigerant containment check to indicate if refrigerant leakage has occurred.
- Each indoor unit must be treated as a individual zone.

48 Option B: System Description for HEAT RECOVERY INVERTER VARIABLE VOLUME SPECIFICATION – **3-PIPE technology**

- Provide simultaneous heating and cooling via a process of heat recovery and re-direction of refrigerant. R410A refrigerant.
- For installation simplicity a maximum use of three refrigerant pipes only
- The BS units switches the system between cooling and heating modes, thus supplying simultaneous heating or cooling.
- Make minimum use of pipe work connections to reduce the possibility of leaks. Minimize the welding to reduce labour required.
- Systems must incorporate an integrated oil recovery process taking only a few seconds.
- System must continue to operate between changes of modes from cooling to heating and vice versa.
- Incorporation of a Night time quiet operation of 49dB on the condensers must be possible.
- Condensers heat exchangers to have Anti-corrosion salt and acid rain protection Blue Fin coating as a standard with Pre-coated galvanized metal casings. Powder coated
- Protection devices must include; High pressure protection: High pressure switch 4.15MPa (601 psi), Inverter circuit: Over-voltage and over-current protection for AC bus & Over-heat protection, Compressor/fan: Over-heat protection/Thermal switch, Condensers are to have maximum of two compressors per system. At least one of these is to be an inverter scroll hermetic compressor.
- The External Static Pressure of the condensers should be a minimum of 60Pa.
- Controllers must have option of automatic group control.
- The internet air conditioning management system must incorporate Ethernet protocol as a standard feature.
- Refnet Joints and headers and insulation for this to be from the same supplier as the in- and out-door units.
- The system must be able to perform a refrigerant containment check to indicate if refrigerant leakage has occurred.
- Each indoor unit must be treated as an individual zone.
- Provide a system capable of diversity between 50-130% of condenser capacity. Select on **115%** if not specifically specified elsewhere.
- All Capacity correction factor calculations to be done by VRS Specialist
- BS Controllers: Galvanized metal casing. HVAC contractor to ensure that a condensate drain point and 220V isolator is supplier adjacent to controllers. Must have PC board fuse and be complete with fixing brackets.

49 The VRS shall be factory tested with a certified quality assurance system and shall be manufactured in a facility with an ISO 14001 certified environmental management system.

50 If doubt exists as to the scope and requirements of the control system, tenderers are to directly contact the consulting engineers prior to submission of the tender price

51 Controls, safeties and diagnostics Controls

- Unit controls shall include as a minimum: microprocessor, LOCAL/OFF/REMOTE switch, and a 6-digit diagnostic display with keypad.
- Shall be capable of performing the following functions:

(a) Automatic compressor lead/lag switching

(b) Capacity control based on leaving chilled fluid temperature with return fluid temperature sensing

(c) Limiting the chilled fluid temperature pull-down rate at start-up to an adjustable range of 0.1ºC to 1.1ºC per minute to prevent excessive demand spikes at start-up.

(d) Enable adjustment of leaving chilled water temperature according to the return water temperature or by means of a 0-10 V signal to the outdoor temperature.

(e) Provide a dual set point for the leaving chilled water temperature activated by a remote contact closure signal.

(f) Enable a 2-point demand limit control (from 0 to 100%), activated by a remote contact closure of a 0 to 10V signal.

(g) Control water pump(s) operation.

(h) Enable automatic lead-lag of two chillers in a single system.

- Diagnostics

(a) Display module shall be capable of displaying set points, system status (including temperatures, pressures, run time and percent loading) and any alarm or alert conditions.

(b) Control module, in connection with the microprocessor, shall be capable of displaying the output of a full load run test to verify operation of every switch, sensor, fan and compressor before chiller is started.

- Safeties :Unit shall be equipped with all necessary components, and in conjunction with the control system shall provide the unit with protection against the following:

(a) Loss of refrigerant charge.

(b) Reverse rotation.

(c) Low chilled fluid temperature.

(d) Low oil pressure (per compressor).

(e) Voltage imbalance.

(f) Ground current fault.

(g) Thermal overload,.

(h) High pressure.

(i) Electrical overload,

(j) Loss of phase.

(k) Current imbalance.

(l) PC Board Fuse

- Fan motors shall be individually protected by a circuit breaker.
- Control shall provide general alarm remote indication for each refrigeration circuit.
- Control system shall have a RS485 serial output port.
- Additional controls required as detailed later in this specification.

52 Operating characteristics

- Unit shall be capable of starting and running at full load at outdoor ambient temperatures from 0ºC to 35ºC.
- Unit shall be capable of starting up with 25ºC entering fluid temperature to the evaporator.

53 Electrical requirements

- Unit electrical power supply shall enter the unit as per manufacturer's requirements.
- Outdoor Unit shall operate on 3-phase power supply.
- Unit with two compressors shall have a factory-installed, star-delta starter to minimize electrical inrush current.
- Control voltage shall be supplied by a factory-installed, non-fused electrical disconnect for the power supply.

54 Indoor Units

- Coils to be copper tube with aluminum fins. The fins shall be surface coated with a corrosion inhibiting substance, preferably factory applied.
- Each unit is to be fitted with a return air plenum. Filters are to be easily removable from the units from the bottom or from the side (clip in/out), and to be removable, washable PP honeycomb fabric, 15-20mm wide,
- Insulated formed watertight corrosion resistant drip trays below coils.
- The unit casing is to be insulated with minimum 10mm high-density self-fire extinguishing material.
- Direct driven fan motor, variable speeds as standard.
- External casing to be galvanized
- Condensate drains to be provided with suitable cleanable trap to prevent transfer of smells from the drainage system and where possible is to use the trap of a wash hand basin. A short length of transparent tubing is to be provided at the connection to the drain pan. All drain lines are to have a suitable fall to prevent standing water. Note that Condensate drain pump kit are specified on all models. Ensure that condensate pipe is suspended every 800-1000mm and the fall to be 1:100 or better, and ensure the collective drain pipe is big enough.
- Sound pressure levels of each model of the FCU will be required at time of material submittal
- The final handing and coordination of the FCU is the contractor's responsibility.
- Storage strictly to supplier's recommendations.
- Fan motor, scrolls and wheels to be easily removable in-situ.
- Units are to be supported on anti-vibration mounts or rubber "grommets" to prevent vibration being transmitted into the slab over.
- The HVAC sub-contactor to ensure that the hide away unit selection takes the pressure drop over the duct and diffuser into account. Detail calculations to be submitted to the Consultant.
- The schemes indicated on the tender drawings are indicative only of the preferred ducting and piping routes co-coordinated by the Professional Team.

- The HVAC sub-contractor is responsible for selecting all direct expansion split units, which are to meet the specified cooling capacities at the design on coil and ambient conditions.
- All refrigerant pipe sizing, positioning of all condensing units and the responsibility for ensuring that the manufacturer's maximum recommended refrigerant piping length is not exceeded, remains the HVAC sub-contractor's responsibility.
- Provide access to filter, fan and motor drip tray, valves and controls.
- No materials shall be used, that encourages the growth of bacteria and fungi in the presence of moisture.
- Fan Coil Units shall be selected at medium speed to provide the specified capacities at against the system resistance specified (Use ESP 40 Pa if nothing specified).
- The maximum coil face velocity of the Fan Coil Unit not to exceed 300 fpm (1.5 m/Sec).

5.23. WALLS / CEILING FANS

1 The industrial wall fan shall be from the Select range of HOWDIN DONKIN, WOODS, VENTAXIA, PENN , ELTA or SYSTEMAIR FANS.

2 Each fan unit shall comprise a tough heavy duty internal aluminium louvre grille, an adjustable galvanised steel wall sleeve, high efficiency plate axial fan and air operated external all weather louvre.

3 All-weather louvres shall have vanes that open automatically when fan airflow commences. Louvres are manufactured in durable polypropylene and finished in light grey.

4 The internal louvre grille is manufactured in aluminium with a white epoxy powder coated finish.

5 A telescopic wall liner customised from galvanised sheet steel shall be adjustable from 230mm to 390mm which has a cut-out to allow concealed cable entry.

6 Adjustable pitch aerodynamic impellers shall be provided, made from high quality GRE These shall be factory set at an angle to provide maximum performance. Hubs shall be made from die cast aluminium alloy (LM24).

7 Highly efficient, light weight induction motors shall be provided, these will have sealed for life, maintenance free ball bearings. Each motor shall be matched to the aerodynamic performance of the impeller. Motors shall be class 'F' insulated to EN 60034-5 and suitable for speed control. They shall have an integral thermal overload protection. The fan shall be suitable for operating temperatures of up to +70°C fixed and +50°C when used with a speed controller. Electrical connections to the motor shall be provided by an lP55 rated terminal box supplied with the fan.

8 All fan units are to be designed and manufactured with procedures as defined in BS EN ISO 9 001:2000. EEC directives shall be met.

9 All fan units are to be tested to ISO 5801:1997 (airside performance) and BS 848 pt 2:1985 (sound performance).

10 Fans must include the necessary ceiling and wall kits, and mounting brackets.

5.24. WATER PUMPS

1 The pumps shall be **KSB, HOLDEN & BROOKE, INGERSOLL or ITT BELL& GOSSETT**, **GRUNDFOS, RAPID ALLWIELER, WILO, SALMSON, LOWARA, HOWDEN.** Localised agencies with service centres must be present in South Africa in all main towns.

2 Water Pumps shall be sized by the Air Conditioning Contractor to handle the required water quantity against the calculated total head pressure while operating at an efficiency of not less than 55%. The pumps shall have duties as specified, but it should be noted that the system resistance ordered is provisionally stated and subject to the air conditioning equipment. The Contractor is therefore required to recalculate the system resistance taking into consideration the actual pressure drops through equipment that is finally ordered and satisfy himself that the resistance figures for the pumps are adequate.

3 Each pump is therefore required to deliver the stated volume flow rate against the "actual" system resistance, and subsequent extra payment shall not be considered against any required amendments to pump duty. The Contractor shall verify the system resistance and agree it with the Engineer prior to placing orders.

4 Pumps must be inline similar to GRUNDFOS TP model.

5 Water Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the vertically split, single suction type having the casing secured directly to the bedplate and operating at a rotational speed not exceeding 1500 r.p.m. A drained stainless steel drip pan is to be provided under each pump.

6 Water Pumps having discharge connections not exceeding 75mm may be of the close coupled type in which the impeller is overhung on the motor shaft or of the bracket-mounted type in which the casing is overhung from the bearing bracket. Pumps of either type shall operate at a rotational speed not exceeding 1450 r.p.m.

7 Casings shall be designed for a working pressure of 6 bar OR 1,5 times the actual discharge pressure OR as specified in the pump schedule, whichever is greater. Pressure classification of flange connections shall correspond to casing working pressures.

8 High points of pump casings shall be provided with air vent cocks. Low points of casings shall be provided with valved drains and inlet and outlet connections shall be provided with properly located gauge tappings. Casing brackets of vertically split pumps equipped with stuffing boxes shall be arranged to form drip pockets. A drip pipe shall be run from each drip pocket and shall terminate over the nearest drip funnel or floor drain.

9 Impellers shall be bronze and shall be dynamically balanced. Impellers of pumps having 40mm and larger discharge connections shall be fully enclosed and hydraulically balanced.

10 Shafts for pumps with mechanical seals shall be stainless steel, monel metal or shall be carbon steel with sleeves of bronze, chrome iron or nickel iron extending through

the mechanical seals. Shafts shall be provided with water slingers where mechanical seals are used.

11 Bearings for close coupled pumps shall be of the ball or roller type. Bearings for all other pumps shall be either ball or roller type, or ring oiled or wool packed sleeve bearings with ample oil reservoirs. Thrust bearings shall be of either the ball or Kingsbury type. Bearings shall be effectively sealed to prevent loss of oil and entrance of dirt or water.

12 Stuffing boxes will not be accepted by the Engineer.

13 All pumps, other than close coupled pumps, shall be provided with suitable flexible couplings with earthing straps. Couplings shall impose no restriction on normal end play or expansion.

14 Pumps shall be factory-assembled by their suppliers, together with their driving motors on a common welded steel bedplate fabricated from mild steel channel sections. Bedplates shall be robustly constructed and free from distortion. Machine spacer plates or shimstock shall be used to align the pump and motor. Drives and associated guards shall comply with the relevant sections of the specifications, drives being works-aligned and alignment rechecked after installation of the pumps on site, immediately prior to setting into operation.

15 Water Pumps shall be supplied as complete sets by their suppliers, incorporating pumps, bronze impellers, motors, drives, bedplates, stainless steel drip trays etc., factory assembled and despatched to the project complete in all respects.

16 Pump and motor and baseplate assemblies shall be fully flow tested at factory prior to dispatch, at design duty, and test results shall be forwarded by the Contractor for incorporation in the Operating and Maintenance Instruction Manuals

17 Each pump shall have a stainless steel drip tray with welded comer joints (shot or sand blasted, painted 2 coats red oxide primer and 2 coats gloss finish after fabrication) located on the concrete plinth and below the pump baseplate. This drip tray shall be complete with 20mm copper discharge pipe, extending to the nearest floor drain. The drip tray shall be fabricated from 1mm thick sheet steel, and shall extend beyond the concrete base at one end by 100mm to facilitate the outlet connection from the bottom.

18 Pumps shall be fitted with Glycerine filled pressure gauges of bronze casing and 100mm diameter dial, complete with gauge-cocks and anti-siphon tubes, fitted to suction and delivery connections. The gauges shall be calibrated in both "Bar" and "meters water gauge" and the operating point shall be mid-way in the dial range of calibration. (Note: negative reading required for pump suction).

19 Pumps shall be selected such that the specified duty may be achieved using an impeller size and pump body which may in future be upgraded to increase the pump duty. In other words, the impeller shall not be the maximum size which may be fitted into the particular pump body. In this case, the next larger size pump shall be selected.

20 The pumps shall be entirely suitable for continuous operation in temperatures of 45 degree C.

21 Each pump shall be fitted with rubber sphere type vibration isolators on suction and delivery pipework connections. These shall be supplied an approved manufacturer.

22 Hot water pumps must have seals to enable it to run without any problem at 100*C.

23 Pumps standing outside must be IP55 rated.

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