SUBJECT DEFINITIONS AND ABBREVIATIONS

PART C1.5 SECTION 01 PAGE 1 OF 2

1. DEFINITIONS:

The following terms shall, unless the context otherwise requires, have the meanings hereunder assigned to them:

'Balancing' Work adjustments and checks necessary to proportion the flow within the distribution system (sub-mains, branches, terminals) in accordance with specified design quantities.

'Commissioning' Work necessary to place the installation and work covered by this specification into normal operating condition.

'Concealed' Embedded in masonry or other construction, installed in furred spaces within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

'Exposed' Not installed underground or concealed as defined above.

'Indicated' As indicated, shown or noted on drawings and/or specifications.

'Install' To erect, mount and connect complete with all related accessories.

'Provide' To supply, install and connect up complete and ready for safe operation.

'Similar' or 'equal' Of approved manufacture equal as regards to materials, weight, size and efficiency of performance to product specified by name.

'Supply' To purchase, procure, acquire and deliver complete with all related accessories.

'Testing' Work and checks necessary to determine qualitative and quantitative performance of equipment, installation and workmanship.

'Wiring' Conduit, fittings, wiring, junction and outlet boxes, switches, cut-outs and socket outlets and all related items.
2. **ABBREVIATIONS**

Abbreviations used in these documents shall mean:

- 'ASIB' Automatic Sprinkler Installation Bureau.
- 'AFI' Air Filter Institute.
- 'AMCA' Air Moving and Conditioning Association.
- 'ASA' American Standards Association.
- 'ASHRAE' American Society of Heating, Refrigeration and Air Conditioning Engineers.
- 'ARI' Air Conditioning and Refrigeration Institute (USA).
- 'ASME' American Society of Mechanical Engineers.
- 'AWWA' American Water Works Association.
- 'BSI' British Standard Institute.
- 'BS CP' British Standard Code of Practice.
- 'CIBS' Chartered Institution of Building Services.
- 'DIN' German Standards Institute.
- 'HVAC' Heating and Ventilating Contractor's Association (UK).
- 'NBFU' National Board of Fire Underwriters (USA).
- 'NBS' National Bureau of Standards (USA).
- 'NEMA' National Electrical Manufacturers Association (USA).
- 'NFPA' National Fire Protection Association (USA).
- 'N/S' Nominated/Selected
- 'SABS' South African Bureau of Standards.
- 'SICO' Safety, Instrumentation, Control, Operation.
- 'SMACNA' Sheet Metal and Air Conditioning Contractors National Association, Inc USA).
- 'TBC' Testing, Balancing and Commissioning.
- 'UL' Underwriters Laboratories.
1. GENERAL

1.1 The contract works to be carried out consists of the engineering, manufacturing, supply, delivery, offloading, erection, testing, balancing and commissioning into service, guarantee and maintenance of an air conditioning and/or ventilation installation as described in the document and as shown on the drawings.

1.2 The engineering, quality control and inspections, equipment selection, preparation of shop drawings, testing, balancing, commissioning and preparation of operating and maintenance manuals, are to be executed in a systematic manner, once programmed, under the Engineer’s general supervision and direction.
SUBJECT DRAWINGS AND SUBMISSIONS

PART C1.5 SECTION 03 PAGE 1 OF 2

1. ENGINEER'S DRAWINGS

1.1 The drawings prepared by the Consulting Engineer show general layout of all equipment and distribution systems, complete with schematic arrangements. These, together with the specification, give sufficient information to enable the Subcontractor to estimate the cost and to determine how the system must be installed, tested, balanced, inspected, operated, serviced and maintained.

1.2 These drawings are not dimensioned Shop Drawings, and cannot be used as Shop Drawings. Location dimensions shown are only indicative of the routes and zones in which the service must be installed.

1.3 Design/Selection/Construction Details and Installation Arrangements for Equipment and/or Distribution Systems which are available from either the Manufacturer/Supplier in their officially published literature/documentation, design/application manuals, or other authoritative sources such as:

1.4 1) SABS  2) C.I.B.S.  3) ASHRAE  4) SMACNA  5) Kendrick (USA)

shall be used as the basis for Shop Drawings and specific source identified at submission stage.

1.5 Where these details are non existent or not sufficient, reference might be made to the Sections and Detail Drawing.

2. SUBCONTRACTOR’S DRAWING, EQUIPMENT SELECTION AND SAMPLE SUBMISSIONS

2.1 SHOP DRAWING SUBMISSIONS

2.1.1 Shop Drawings shall indicate all equipment, distribution systems, testing/inspection/instrumentation positions, access requirements and builder's work requirements.

Builder's work requirements shall include all work to be provided by others (holes in concrete and masonry bases, etc) as well as the sizes, capacities and positions of service connections.

2.1.2 Shop Drawings shall be based on the Engineer's design concept shown on the tender drawings, approved equipment selections and samples. The Shop Drawings shall be checked and passed by the Subcontractor's Chief Draughtsman and Project Engineer/Manager. The Shop Drawings shall be stamped to confirm that co-ordination with Architects, Structural and other affected Sub-contractor's drawings, has taken place.

2.1.3 Copies of Shop Drawings of all parts of the subcontract works shall be submitted to the Engineer for approval.

2.1.4 Shop drawings shall indicate all support and fixing details to be used.

2.1.5 The Subcontractor may, if he so desires, obtain “electronic /e-mail” copies of the Engineer's drawings for modifications and updating if required. These drawings shall be re-titled in accordance with the Subcontractor's system and shall thereafter be submitted as the Sub-contractor's Shop Drawings. No portion of the Sub-contractor's works shall be commenced until the shop drawing has been approved by the Engineer.

2.2 “AS BUILT” DRAWING SUBMISSIONS

2.2.1 “As Built” drawings are the Shop Drawings embodying all modifications made during construction. They shall include floor- and ceiling layout drawings indicating all terminal and/or fan coil units and/or controller positions. SICO drawings are also “As Built” drawings indicating the intended functioning, capacity data and control functioning of all systems.

2.2.2 Copies of “As Built” drawings shall be submitted to the Engineer for approval.
2.3 EQUIPMENT SELECTION SUBMISSIONS

2.3.1 The Subcontractor shall select equipment which complies with these specifications. These selections shall be submitted to the Engineer for approval.

2.3.2 No equipment shall be installed until the equipment selection submission has been approved by the Engineer if the selected equipment deviates from the design concept and/or deviates from the accepted equipment offered.

2.4 SAMPLE SUBMISSIONS

Samples are any samples required by the Architect or Engineer. Samples shall be physical examples to illustrate materials, equipment or workmanship, and to establish standards by which the works may be judged. Such samples, after approval, will be retained by the Architect or Engineer for a period sufficient to ascertain that the relevant component is actually provided as per such sample, but will then be returned to the Subcontractor for incorporation in the works.

3. SUBMISSION PROCEDURES

3.1 Submission for approval will consist of the following activities executed by the Subcontractor and other parties involved:

3.1.1 The Subcontractor shall review, stamp, date and sign to signify his approval and submit in the manner required by the Engineer and with reasonable promptness and in orderly sequence so as to cause no delay in the work, all Subcontractor's drawings, equipment selections and/or samples required by the Subcontract documents or subsequently by the Architect or Engineer. Subcontractor's drawings, equipment selections and samples shall be properly identified as specified or as the Architect or Engineer may require.

3.1.2 At the time of submission the Subcontractor shall inform the Engineer in writing of any deviation in the Subcontractor's drawings, equipment selection or samples from the requirements of the subcontract documents.

3.1.3 Each individual Equipment Selection Submission shall be accompanied by a copy of the applicable detailed technical specification. Each clause of this specification shall be marked "complies" or "Does not comply", complete with reason stated and countersigned by the Subcontractor's Project Engineer/Manager.

3.1.4 Equipment Selection Submissions shall be indexed similar to the index for Part II - Equipment of the "Operating Instructions and Maintenance Manual" as described under Section 18 of Part C1.5 in order to form part of the O&M Manual.

3.1.5 The drawings and Equipment Selections shall be submitted in a number of copies and along the channels agreed.

3.1.6 By submitting drawings, Equipment Selections and/or samples, the Subcontractor represents that he has determined and verified all site measurements, site instruction criteria, materials, catalogue numbers and similar data, or will do so, and that he has checked and co-ordinated each Contractor's drawing and sample with the requirements of the Works and of the Subcontract documents.

3.1.7 The Engineer, on behalf of the Contractor, will review Subcontractor's drawings, Equipment Selections and samples with reasonable promptness so as to cause no delay, but only for conformance with the design concept of the Subcontract Works and with the information given in the Subcontract documents. The Engineer's approval of a separate item shall not indicate approval of an assembly in which the item functions.
3.1.8 The Subcontractor shall make any corrections required by the Engineer and shall re-submit the required number of corrected copies of the Subcontractor’s drawings, Equipment Selections or new samples until approved. The Subcontractor shall direct specified attention in writing on resubmitted drawings to revisions other than the corrections required by the Engineer on previous submissions.
1. GENERAL

1.1 The following related work to the air conditioning and ventilation (HVAC) contract will be provided by others. The HVAC 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.

1.2 Instructions for HVAC Contractor's exact requirements shall be transmitted to the Contractor timeously in the form of builder's and associated services drawings in accordance with an agreed Contractor's 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 Contractor.
1. GENERAL

The Subcontractor shall comply with all Acts of Parliament and all regulations and bylaws of local and or other authorities having jurisdiction regarding the execution of the N/S works in particular the following:

1.1 SANS 10142, as amended, for the Wiring of Premises.


1.3 Occupational Health and Safety Act.

1.4 Government, Provincial and Local Authorities Ordinances, Regulations, By-Laws, Rules and other Statutory requirements.

1.5 Specifications and Codes of Practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practice.
1. GENERAL

1.1 The installation in its entirety shall comply with regard to electrical safety and supply interference suppression requirements, with SABS and/or local authorities’ by-laws, and/or Post Office regulations.

1.2 All safety devices shall be tested in the presence of the Subcontractor’s responsible Project Engineer under the simulated or actual fault conditions for which the safety devices are installed to prevent damage to system equipment and/or building. Confirmation of proper functioning of these safety devices shall be in the form of signed inspection reports from Subcontractor’s Project Engineer.

2. FIRE HAZARD

2.1 Satisfactory test results from the National Building Research Institute or test reports from an approved testing laboratory are required, to certify the fire hazard ratings for proposed materials for insulation, covering and vapour sealing.

2.2 Such fire hazard ratings shall be as determined by the National Building Research Institute of the South African Council for Scientific and Industrial Research, and in accordance with test procedures of BS 476.

2.3 Insulating materials, finishes, vapour barriers and adhesives shall conform to the fire hazard ratings specified as follows:

2.3.1 The fuel contribution index shall not exceed 0 when compared with asbestos taken as 0.

2.3.2 The smoke contribution index shall not exceed 10 when compared with hardboard taken as 100.

2.3.3 The spread of flame index shall not exceed 0 when compared with asbestos taken as 0.

2.4 Any products of combustion of said materials shall be completely non-toxic and non-corrosive.
SUBJECT  HOISTING AND RIGGING

PART C1.5  SECTION 07  PAGE 1 OF 1

1. HOISTING

If at time of tendering the Contractor is known, the tenderer shall check with the Contractor which of his proposed equipment could be hoisted by the Contractor and at which cost.

If the Contractor is not known, the Tenderer shall make due allowance for the hoisting of his equipment in terms of Clause 21.3 of the N/S Subcontract agreement.

2. RIGGING

The Tenderer shall be responsible for rigging of his equipment in position.
1. GENERAL

1.1 All materials shall be new, undamaged, free of rust or other defects and shall be of the best quality. Materials shall comply with the relevant SANS or BS specifications where applicable. The contractor shall upon the request of the engineer, furnish him with documentary proof to his satisfactions that the materials are of the quality specified. Samples of materials for testing, if required, shall be supplied by the contractors, free charge.

1.2 The installation as a whole shall be erected in a workmanlike manner, to the satisfactions of the engineer, and shall include all materials and equipment required for the successful operation of the paint specified.
1. PROGRAMMING

1.1 The Subcontractor shall submit to the Engineer within two weeks of appointment, a practicable work programme, based on the building completion date. The programme shall be agreed with and finally incorporated in the Contractor's programme in accordance with the relevant clauses of N/S Subcontract agreement.

This Subcontractor's programme shall state:

1.1.1 Access dates to various plantrooms to start installing sub-system equipment.

1.1.2 Access dates to clean, safe, protected vertical shafts to start modifying main distribution systems linking plantrooms and floors.

1.1.3 Access dates to either ceiling or floor plenums of the different floors (or section of floors) to start installing the sub-distribution systems (so called 1st Fix).

1.1.4 Access dates to the various rooms with completed walls and partitioning (fully cleaned out) to start installing room terminals and connect these to the sub-distribution systems (so called 2nd Fix).

1.2 The section of the programme covering submission of Structural and Installation Drawings, equipment selection, submission of inspection reports of completed sections of the installation, preparation of Operating Instructions and Maintenance Manuals, Testing, Balancing and Commissioning shall be presented in the form of a GANT CHART.

1.3 The network graphic representation must clearly depict the sequence of the activities planned by the Subcontractor, according to the Contractor's requirements, their interdependence, and time required to perform each activity. In developing the project network, the Subcontractor shall use arrow or precedence notation (on which available computer programme are based).

1.4 The Subcontractor shall furnish with the initial programme, a tabular listing of all activities listed on the programme. For each activity there shall be listed the earliest and latest finish times and the "float". Activities on the critical path shall be so indicated.

1.5 The Subcontractor shall regularly, throughout the progress of the works, amend and update the work schedule (both the network graphic representation and the tabular list of activities) to incorporate all variations, new drawings and site instructions, and all such amendments are to be subject to the Contractor's approval and shall not amend the completion date of the project unless extensions of time have been granted by the Contractor.

1.6 If, in the opinion of the Contractor, the Subcontractor falls behind the programme, the Subcontractor shall take such steps as may be necessary to improve his progress. The Main Contractor may require him to increase the number of shifts and/or overtime operation, days of work and/or the amount of construction plant, and to submit for approval revised programmes in the form required above in order to demonstrate the manner in which the required rate of progress will be achieved, all without additional cost to the Employer.

1.7 Regular meetings to monitor progress will be held under the chairmanship of the Contractor. The meetings must be attended by as many of the representatives of the Subcontractor as the Contractor shall require.

1.8 The purpose of such meetings will be to review progress against the programme, to investigate and establish actual or impending causes of delays, to instruct on such remedial action as may from time to time be necessary and generally to ensure that the progress of the work remains on programme at all times.
1. CONTRACT MANAGEMENT

1.1. All activities, information required, approvals, etc. shall be managed by the officially appointed Subcontractor's Project Engineer/Manager to ensure completion of the Subcontract at the agreed completion date and of specified quality.

1.2. It shall be the duty and responsibility of this Project Engineer/Manager to identify any item such as delays, activity time overrun, late information and/or approval at least fortnightly, and describe in his standard report to the Contractor proposed action to overcome the adverse conditions to maintain the planned construction schedule.

1.3. It shall be the duty and responsibility of this Project Engineer/Manager to prepare a detailed tabulated construction activities breakdown with related earliest and latest dates for information required, approval, area availability and inspection.

Construction activities are:

1.3.1. Drawing Submissions.
1.3.2. Equipment Selection Submissions.
1.3.3. Off Site Manufacturing.
1.3.4. Installation on Site.
1.3.5. Testing, Balancing and Commissioning Procedures Submission.
1.3.6. Testing, Balancing and Commissioning of the Works.

1.4. The Project Engineer/Manager shall monthly, throughout the progress of the Subcontract, amend and update the 'tabular list of activities' to incorporate all variations, delays and remedial action to ensure that the completion date will be met. He shall particularly note and report to the Contractor on unusual conditions encountered which may (or has) delayed progress of the work related to the contractor's programme.

1.5. The Project Manager shall monthly report to the contractor, with copies to the Architect and Engineer, in writing only and shall sign each progress report, equipment submission, drawings and inspection checklists.

1.6. The Project Manager shall be capable of using network diagrams to explain the sequence and actual dates used by him in his tabular form monthly report in order to prove that 'cut-off' dates are realistic and factual and not an attempt to formulate claims for delays.

1.7. On the request of the Engineer and/or Contractor, the subcontractor shall remove from the works a person who is negligent in his contractual obligations.
1. **ORGANISATION AND STAFF OF SUBCONTRACTOR**

   In addition to the Site Supervisor/Foreman, the Subcontractor shall employ, (apart from the required artisans and labourers), as many trustworthy and experienced engineers, programmers, inspectors and administrators as may be necessary for the purpose of the subcontract.

2. **DUTIES**

   The duties and responsibilities of the Subcontractor Engineering and Management Staff shall be inter alia:

   2.1 Programming of the works in agreement with the Contractor as per N/S Subcontract agreement.

   2.2 Directing his employees to ensure efficient, timely and safe execution of the work, and co-operation with the Contractor and other trades to ensure such execution.

   2.3 Selection and/or engineering of equipment and components into working assemblies all in conformance with the design concept contained herein.

   2.4 Equipment Selection and submissions of Installation Drawings for approval in accordance with the required procedures.

   2.5 Expediting of the work.

   2.6 Attendance of routine site progress meetings and programme monitoring meetings which may be arranged by the Contractor.

   2.7 Preparation and submission of Testing, Balancing and Commissioning Procedures and Programming.

   2.8 Provide assistance to the Engineer during QA inspections in opening ceilings, floor files, access hatches etc and providing access to HVAC equipment.
1. GENERAL

1.1 Special care shall be taken in transport, delivery, storage on site and installation to ensure that the entire system is in ‘as new’ condition at start-up. Equipment damaged in transit or during installation will not be acceptable and shall be replaced.

1.2 Packaging material shall be of sufficient strength and/or temporarily reinforced during transport to - and handling on site, until installed in its final position, to ensure that the equipment “packed” retains its structural and dimensional integrity during these phases of the contract.

1.3 The Subcontractor shall remain responsible for equipment in ‘as new condition’ and is not allowed to install equipment in areas or spaces where it can be subjected to damage through weather or trades for which it has not been designed.

1.4 The Subcontractor is only allowed to install equipment intended for internal use if the following pre-installation requirements are met:

   1.4.1 Areas are sealed and protected from outside weather -(facade and roof closed and finished).

   1.4.2 All wet building trades are finished inspected and accepted by Contractor so that no further remedial patch-up work by building trades is required.

   1.4.3 The areas are clean, isolated and secure (no other trades’ material and labourers cross-traffic) and protected against possible damage and pilferage.

1.5 Damage caused by the contractor, or his servants, agents or workmen to the building, structure or any other service, shall be rectified to the satisfaction of the engineer, by and at the expense of the contractor.

1.6 Equipment delivered to site shall be stored in a well protected area where it cannot be damaged by either the weather or other trades.
1. GENERAL

1.1. The Subcontractor shall familiarise himself with the proposed location of the equipment and shall be responsible for ensuring that sufficient access is available on site to allow the largest component parts to be brought into position.

1.2. The required unobstructed space shall be left around the equipment for access, maintenance and service of the equipment in accordance with the manufacturer's instructions.

1.3. Equipment shall be installed so as to be readily accessible for testing, operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra costs shall not be made without approval of the Contractor.

1.4. Platforms and ladders shall be provided for access to instruments and equipment requiring maintenance.
SUBJECT: CLEANING AND START UP

PART C1.5  SECTION 14  PAGE 1 OF 1

1. GENERAL

1.1. Repaired equipment/components will be accepted at "handover" of system if defects become apparent during start-up, testing and commissioning only at the discretion of the "Engineer".

1.2. No pumps, fans or other power driven equipment are allowed to be started-up unless screens, filters, strainers, etc are installed and checked to prevent damage to the rotating/reciprocation equipment.

1.3. All necessary system cleaning, flushing, must be completed before system is started up and control valves activated.

2. PRE-START PROCEDURE

2.1 WATER SYSTEM

Provide temporary connections between flow and return connections of fan coil units such that flushing water shall not flow through any fan coil unit, coil or control valve. Remove temporary connections after cleaning is completed. Remove metering orifices in chilled water lines before pumped cleaning operation takes place and re-install after cleaning is completed.

2.2 AIR SYSTEM

Check for System Cleanliness. Before fitting clean filters and washer elements, check all airways for cleanliness, paying particular attention to:

2.2.1 Air intake screen and louvres.
2.2.2 Fan and other equipment chambers.
2.2.3 Fan internals.
2.2.4 Washer tanks.
2.2.5 Humidifiers.
2.2.6 Cooling coil trays.
2.2.7 Floor gulleys, all drainage systems, and taps.
2.2.8 Dampers.
2.2.9 Terminal units (grilles, diffusers, etc).
2.2.10 Sensing elements (thermostats, humidistats, etc). Ductwork internally and as far as physically possible. Heating and cooling coils.
2.2.11 Eliminator sections.
2.2.12 Mixing boxes.

Complete and submit Pre-start and Checklists for all the sub-systems similar to the example for a Primary Air Sub-System - as per Part C1.5 Section 21.
1. **GENERAL**

1.1. Concurrent with equipment submissions the subcontractor shall submit full testing, balancing and commissioning procedures for each item of equipment.

1.2. Prior to the pre-start inspection the subcontractor shall submit, and have obtained approval of a fully detailed commissioning programme.

   The programme shall include but may not be limited to the following:

   1.2.1 Checking and setting of all safety features and proving operating by simulation of overload or abnormal conditions.

   1.2.2 Setting and recording of all protective devices allowing efficient and safe operation. All settings and operating points to be recorded on SICO drawings.

   1.2.3 Full and part load tests of the system through summer and winter operation. Operating points of ammeters, thermostats and controllers, etc. to be recorded on SICO drawings.

   1.2.4 Method of adjustments to correlate operating point with chosen point of application on the performance curves of equipment.

   1.2.5 Balancing of systems. Systems shall be checked and results recorded at design conditions.

   1.2.6 Checking the performance criteria by plotting it on the original selection curves of all equipment.

1.3. After physical completion of the subcontract works the Subcontractor shall carry out all preliminary tests necessary to satisfy himself that the plant, materials and equipment comply with the provisions of the subcontract and are in a state suitable to satisfy the requirements of the acceptance tests by the Engineer. The preliminary tests shall then be completed satisfactorily before the Subcontractor, through the Contractor, requests the Engineer to witness the acceptance tests.

1.4. The Engineer may request the Subcontractor to replace any portion of the subcontract work which does not conform to the requirements of the subcontract documents.

1.5. In the event of the plant or installation not conforming to the requirements of the subcontract documents, the Employer shall be at liberty to either recover from the Subcontractor or to deduct from the subcontract price all reasonable expenses incurred by himself or his agents attending the repeated test.

1.6. After physical completion has been reported and all defects made good, "start-up" shall take place and the above check-out procedures shall be carried out.

1.7. Prior to the carrying out of acceptance tests, the Subcontractor shall operate the entire system for as long a period as may be required to provide satisfactory performance at all times in the occupied spaces served by that system for up to 24 hours a day continuously.

1.8. The Subcontractor’s Operator(s) shall be fully conversant with the plant operation and experienced in running similar installations. The Subcontractor shall train the Employer’s operator(s) to enable them to be responsible for and capable
of operating the plant. Logging of the plant operation shall commence once plant has been commissioned and the Subcontractor shall continue logging until the acceptance tests have been carried out and the plant handed over.
1.9. The Subcontractor shall also log, as part of his commissioning, the outside air, supply air and room temperatures. These shall be recorded by continuous printout temperature recorders measuring the various temperatures simultaneously. Temperature recordings shall be taken over a minimum period of fourteen days at various positions designated by the Engineer.

1.10. All tests shall be recorded in a field test report for insertion in the operating instructions and maintenance manual. Values of operating pressure, temperature and amps shall be marked on gauges and instruments as appropriate, and recorded on SICO drawing.

1.11. Marking operating values (temperatures, pressures, amps, etc.) on gauges and thermometers as appropriate.

1.12. The factory testing, balancing and commissioning report shall be supplied with each unit to site. The field testing, balancing and commissioning report shall be signed off by the Employer or his representative.

1.13. Compile a factory and field test report of the above tests for inclusion in the operating and maintenance manual.

1.14. All equipment shall be commissioned in strict accordance with the Manufacturers’ instructions.

2. GREEN STAR

2.1 MAN-2 – COMMISSIONING CLAUSES

2.1.1 In addition to the applicable commissioning requirements in this document, the relevant documentation from the Independent Commissioning Agent has been attached as an Addendum and must be referred to for all commissioning.

2.1.2 Comprehensive pre-commissioning, commissioning as well as quality monitoring shall be done on all the mechanical systems in a systematic manner and in exact accordance with CIBSE / ASHRAE Commissioning Codes, as follows:

2.1.2.1 CIBSE Code A – Air Distribution;
2.1.2.2 CIBSE Code B – Boilers;
2.1.2.3 CIBSE Code C – Automatic Controls;
2.1.2.4 CIBSE Code M – Management;
2.1.2.5 CIBSE Code R – Refrigerant Systems and
2.1.2.6 CIBSE Code W – Water Distribution Systems
2.1.2.7 ASHRAE Guideline 1-1996 – The HVAC Commissioning Process

2.1.3 After completion of the contract, the sub-contractor shall be required to provide training on all the systems to the building management staff to ensure that they have all the information and understanding needed to operate and maintain the features and systems in the building.

2.1.4 The following documentation will be required:

2.1.4.1 Design intent report;
2.1.4.2 As-built drawings;
2.1.4.3 Operational and Maintenance Manuals;
2.1.4.4 Commissioning Records; and
2.1.4.5 Commissioning Reports for each system
2.2 COMMISSIONING REPORT

The Commissioning Reports must:

2.2.1 Demonstrate that the services were commissioned in compliance with CIBSE / ASHRAE Commissioning Codes for all services;

2.2.2 Include commissioning dates, records of all functional/commissioning testing undertaken, a list of any future seasonal testing, and a written list of outstanding commissioning issues;

2.2.3 Include the outcomes and changes made to the building as a result of the commissioning process, accounting for all of the recommendations; and

2.2.4 Reference appended extracts of commissioning records for major plant and equipment (including but not limited to chillers, boilers, heat pumps, air handling units, water treatment/recycling systems and onsite generation systems) as deemed appropriate by the relevant project team members involved in the commissioning process and as referenced in the Commissioning Report.

2.2.5 The Mechanical Subcontractor and Agent will be required to include:

2.2.5.1 Definitive commissioning specifications;
2.2.5.2 Requirements for witnessing including full details of tolerances applicable to all parameters;
2.2.5.3 A commissioning program, including time for witnessing;
2.2.5.4 Health and Safety risk assessment and method statements for the tasks to be completed;
2.2.5.5 Commissioning method statements for each system;
2.2.5.6 Pre-commissioning checklists for each system;
2.2.5.7 Commissioning checklists; and
2.2.5.8 Commissioning certification for each system countersigned by the Engineer and accepting authority including the record sheets provided in each CIBSE / ASHRAE code.

2.2.6 The Operations and Maintenance Manual must describe how the facility will be operated and by whom, as well as the desired level of training and orientation required for the building occupants to understand and use the building systems.

2.3 TRAINING:

2.3.1 In addition, the sub-contractor shall provide training on all the systems to the building owners’ facilities management staff. Full testing and commissioning procedures for individual equipment and for the entire systems shall be submitted.

2.3.2 Training provided must at a minimum include:

2.3.2.1 Information provided in the Design Intent Report (including energy/environmental features);
2.3.2.2 Review of controls set up, programming, alarms and troubleshooting;
2.3.2.3 Review of O&M manuals;
2.3.2.4 Building Operation (start up, normal operation, unoccupied operation, seasonal changeover, shutdown);
2.3.2.5 Measures that can be taken to optimize energy efficiency;
2.3.2.6 Occupational Health and Safety (OH&S) issues;
2.3.2.7 Maintenance requirements and sourcing replacements; and
2.3.2.8 Obtaining and addressing occupant satisfaction feedback.
2.4 TOLERANCES

2.4.1 The indoor climate factors and air flow rates, heating, cooling and humidifying performances, electrical characteristics and other design data shall be measured at the ventilation system design air flow rate.

2.4.2 Tolerances of the measured values in respect of the selection of the measuring equipment are given in the following table:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>UNCERTAINTY*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow rate, each individual room</td>
<td>± 20%</td>
</tr>
<tr>
<td>Air flow rate, each system</td>
<td>± 15%</td>
</tr>
<tr>
<td>Smoke extract</td>
<td>0-20%</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>± 2°C</td>
</tr>
<tr>
<td>Relative Humidity [RH]</td>
<td>± 15% RH</td>
</tr>
<tr>
<td>Air velocity in occupied zone</td>
<td>± 0.05 m/s</td>
</tr>
<tr>
<td>Air temperature in occupied zone</td>
<td>± 1.5°C</td>
</tr>
<tr>
<td>A-weighted sound pressure level in the room</td>
<td>± 3 Dba</td>
</tr>
</tbody>
</table>

* The uncertainties include the permitted deviations from the design values as well as any measuring error.

2.4.3 If the performance of the system requires closer uncertainties, this shall be specially defined in the documentation of the system. If product standards, national or local regulations require closer uncertainties, this shall be adhered to. Refer to control diagrams for additional tolerances.
<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>GUARANTEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART C1.5</td>
<td>SECTION 16</td>
</tr>
</tbody>
</table>

1. **GENERAL**

1.1. The Air Conditioning Subcontractor shall guarantee that the air conditioning and associated systems will be installed and adjusted in such a manner that it will, subject to the capacity limits specified in Part C3 maintain the dry bulb temperatures and humidity levels specified in Part C3 during operating hours.

1.2. Noise levels in rooms caused by the operation of the air conditioning and associated systems, whether generated within the rooms or through duct or floors, etc. shall not exceed the values given in Part C3 at any point within the room.

1.3. The subcontractor shall guarantee the works described in this document against failure of any sort for a period of 12 months of certifying completion of the works.

Any repairs and replacement of parts or equipment during the 12 months guarantee shall be performed without any cost to the Employer.
1. GENERAL

1.1. The tender adjudication will take into account the Tenderers official Quality Manual and Quality Control Systems.

1.2. The manual shall not only describe in detail the qualifications, responsibilities and authority of the proposed Project Engineering, Managing and Quality Assurance personnel but also the firms technical standards and detail procedures for:

   1.2.1 Programme Submission and Contract Management.

   1.2.2 Equipment Selection Submissions.

   1.2.3 Installation/Shop Drawing Submissions.

   1.2.4 Sub-system(s) Testing, Balancing and Commissioning Manual Submission.

   1.2.5 Site Installation Inspection Report Submissions.

   1.2.6 Progress Payments and Evaluation.

1.3. The quality of managing, as reflected in the Subcontractor’s submission of:

   1.3.1 Work programming.

   1.3.2 Equipment selection.

   1.3.3 Shop drawings.

   1.3.4 Testing, Balancing and Commissioning Documentation.

   1.3.5 Operating Instructions and Maintenance Manuals.

   1.3.6 Inspection Record Cards/Checklists.

   shall be in accordance with ISO-9000 or otherwise/approved.

1.4. No portion of the work shall commence before this manual has been approved by the Engineer.
1. PLANTROOM INSTRUCTIONS

1.1 Large scale wiring and sub-system safety, instrumentation, and control operation diagrams shall be mounted near each sub-system in plantrooms. They shall be complete with regard to:

1.1.1 Final Sub-system Schematics
1.1.2 Block Logic Operating Sequence for:
1.1.3 Normal/Abnormal/Emergency Conditions
1.1.4 Written Description of Plant Operation
1.1.5 Sub-system Equipment performance, Instrumentation and Safety Settings
1.1.6 Automatic Control

1.2 The diagrams and operating instructions shall be printed on high quality, non-deteriorating paper, framed behind glass or plastic laminated and located in a properly illuminated position.

1.3 Copies of Government Acts and Local Regulations, as required, shall be mounted within glazed or plastic covered frames in the plantrooms, in positions to be approved by the Engineer.

1.4 Plantroom log sheets shall be provided in each plantroom. The log sheets shall contain operating details of each item of machinery together with provision for performance logging and making service notes.

2. OPERATING AND MAINTENANCE MANUALS

2.1 The Sub-contractor shall furnish to the Engineer before the Works are taken over a draft copy of the Operating and Maintenance Manuals, As Built drawings and Preliminary Commissioning Data for approval or comment.

2.2 Four hard copies and one CD Rom copy of the approved Operating and Maintenance Manuals, As Built Drawings and final Commissioning Data shall be submitted to the Engineer within three months after taking over of the Works. The four hard copies shall be issued as follows:

2.2.1 1 copy to Spoormaker and Partners.
2.2.2 1 copy to client.
2.2.3 1 copy to be housed in a lockable cabinet inside a plantroom.
2.2.4 1 copy to be kept by sub-contractor.

2.3 The manuals shall be comprehensively indexed and bound in loose leaf plastic covers in a blue coloured vinyl plastic folder with the name of the project type written on a card inserted in to a clear plastic covered cardholder on the front cover and back of the file. Files shall be sequentially numbered.

2.4 The manuals shall be arranged in three parts :-

2.2.5 Part I - Systems Operations
2.2.6 Part II - Equipment
2.2.7 Part III - As Built Drawings
3. **PART I – SYSTEMS OPERATION**

This part describes the system in the building broken down in sub-systems, their operation, trouble shooting and corrective action, and monitoring and logging by means of text, graphics, table, flow charts, etc.

The contents of this section of the manual shall be arranged in accordance with the following index and shall contain information requested against each index heading:

- 3.1 Description of the HVAC system in building
- 3.2 HVAC System Operation
- 3.3 Detailed HVAC System Description
- 3.4 HVAC Systems Space Users Instructions

### A. DESCRIPTION OF THE HVAC SYSTEM BUILDING

#### A.1 Total system concept, broken down in sub-system “Blocks”

In form of pure Engineering (Non-building configuration) schematic showing:

1. Plants
2. Processing Sub-system
3. Distribution System
4. Terminals

The same drawing is Pictorial Index for contents of Manual.

#### A.2 Physical location of the HVAC Sub-system and Distribution systems in the building with their Motor control Centres/Switchboard connected loads and integrated control panels.

Coloured drawings, maximum size A3 - with codes, notes and special explanatory isometrics or photographs arranged in the sequence as shown on the master schematic drawing starting from simplest room terminal sub-systems and ending at complex sub-systems in plantrooms. Load Summary Matrix. Estimated maximum demand and electricity consumption for each “plant” monitoring/recording meter.

### B. HVAC SYSTEM OPERATION

#### B.1 Daily starting and stopping instructions

Normal daily starting and stopping of sub-systems in the total system. In the form of sub-system starting sequence block logic flow diagram, showing how sub-systems are started manually and/or automatically.

#### B.2 “Abnormal” Operating Instructions

After hours, emergency, restricted power and plant failure override selection of operation mode of sub-systems. In the form of decision flow diagrams showing the action of the Operator in detail depending on outside conditions, section of building occupied, power available, sub-system failure, etc.
C. DETAILED HVAC SUB-SYSTEM DESCRIPTION

C.1 Normal Sub-system Operation
In the form of sub-system schematic drawing. Drawing with the following five subdivisions:-
  i. Sub-system schematic
  ii. Block logic starting and operating sequence
  iii. Tested equipment performance, measured and recorded inputs and outputs, instrumentation, safety settings, type of capacity control.
  iv. Detailed capacity control description.
  v. Filled in commissioning results on sico.

C.2 Abnormal sub-system operation (equipment and/or control failure).
In the form of a decision flow diagram showing the action of the operator depending on sub-system input conditions, equipment failure, control malfunctioning, etc.

C.3 Sub-system performance log and report forms
For use by system operator/inspector to monitor and report on system performance. In the form of the standard sub-system logging and report form for each sub-system, on which all “normal operating conditions” are listed and against which actual sub-system performance must be monitored.

C.4 Scheduled list of all major plant and equipment
To include Description, Make, Model Number and Suppliers name and address.

D. HVAC SYSTEMS SPACE USERS INSTRUCTIONS

D.1 Tenant circular in the form of decision low diagrams and graphics showing:-
  i. Actions of the tenant when room conditions are too hot/dry/stuffy.
  ii. Relocation of terminals/thermostats due to change in workstation layout.

E. LAYOUT DRAWINGS

E.1 Photographically reduced to size A3, copies of all “As Built” Drawings and Diagrams to include the following:
  i. Plant layout drawings showing the actual positions and sizes of all plant and equipment, ducts and pipes, the location of all dampers, valves and controls and the measured air quantities at all the intake and discharge points.
  ii. Control and wiring diagrams and schematic piping diagrams noting, where applicable, the normal and abnormal gauge readings, control points, scale settings and time settings, differential bands, throttling ranges, time delays and the overload settings and actual rated amperages of all electrical components, and any other relevant variable and adjustable items, to permit checking and adjustment of all instruments, controls and motor functions.

F. OVERALL SUMMARY OF MAINTENANCE / SPARE PARTS

F.1 In schedule form setting out each item of plant, the description and frequency of the required maintenance operations as necessary for preventative maintenance of the plant as installed.

F.2 List of spare parts supplied (In accordance with Supplier’s recommendations with detailed description of each part, make, model or part number and Supplier’s name and address.)
4. **PART II – EQUIPMENT**

This part shall be sub-divided on an equipment basis as sequenced in Project Technical Specification. The following checklist shall be used in indexing and sequencing the Manufacturer’s information and results of final test data.

A. **Description Literature**
   1. Catalogue Cuts, Brochures or Shop Drawings
   2. Dimensional Drawings an Record Drawings
   3. Materials of Construction
   4. Parts of Designation

B. **Operating Characteristics and Commissioning Results**
   1. Performance tables, Charts or Curves and marked Operating Point or Points
   2. Pressure, Temperature and Speed Limitations
   3. Safety devices and Settings
   4. Final approved commissioning results.

C. **Operating Instructions**
   1. Pre-start Checklist
   2. Start-up Procedure
   3. Inspection During Operation
   4. Adjustment and Regulations
   5. Testing
   6. Detection Signals

D. **Inspection Instruction and Procedures**
   1. Normal and Abnormal Operating Temperatures, pressure and Speed Limits.
   2. Schedule and Manner of Operation
   3. ‘Trouble Shooting’ Guides

E. **Maintenance and Instructions and Procedures**
   1. Schedule of Routine Maintenance
   2. Procedure
   3. ‘Trouble Shooting’ Guides.

F. **Parts List**

G. **Spare Parts**
   1. Essential Spares to be Stored by Building Owner.
   2. Distributor Spares

H. **Supplier Data**

I. **Maintenance and Service Contracts**
5. **PART III – AS BUILT DRAWINGS**

In addition to reduced sets of drawings in each set of manuals one set of full scale drawings on high quality paper and CD Rom with DXF files of the drawings shall be provided.

As Built drawings shall be CAD drawings and shall be layered and numbered in accordance with an agreed standard, available on request from the Engineer.
1. **GENERAL**

1.1. The Subcontractor shall furnish free of charge all maintenance on the entire subcontract works for a period of twelve months after completion of subcontract works. Maintenance shall include systematic examination and adjustment of equipment at least once a month.

1.2. The Subcontractor shall in the course of such maintenance, or on call during the maintenance period, repair or replace defective parts, and shall use only genuine parts produced by the manufacturer of the original part.

1.3. The Subcontractor shall supply all replacement parts, lubricants, refrigerant, chemicals, filters, fuses, etc. during the free maintenance period.

1.4. Refer to PART C4.7 for details of the maintenance contract applicable to this subcontract.

1.5. The first year maintenance contract can be extended in accordance with the Detailed Maintenance Specification.
2. GENERAL

1.1. The Subcontractor shall provide a fully qualified technician for a period of two months after handover for re-positioning space terminals like thermostatic controls, terminals, etc to suit the Employers/Tenants requirements.

1.2. During the same period, the technician shall train the Employers Representative so that he will be able to perform the re-positioning on his own after the two months period.
1. GENERAL

Before starting on the Pre-Start Inspection, check that all instruments such as thermometers, pressure gauges, etc. are in the correct position, calibrated and suitable for the range they have to indicate, in accordance with the schematic flow diagrams. Ensure that all relevant schematic prints indicating flows, pressures, temperatures, etc are mounted in the plantroom next to the equipment to facilitate and speed up the testing and commissioning of the installation.

2. DUCTING AND AIRWAYS

Visual check of air regulating devices and other components within airways. Check the following:

- Freedom from damage to coil fins, acoustic linings, and sensing elements
- Pinning to damper spindles
- Damper clearances
- Damper seating
- Freedom of damper movement
- Position of damper blades with respect to quadrant indication
- Relative positions of blades in multiple leaf dampers
- Setting of terminal air distribution devices in anticipated positions
- All dampers secured in open position with the actuator disconnected if motorized
- Free movement to fire dampers
- Splitter dampers in open position
- Location to, access to and fitting of fusible link assemblies
- All splitters, turning vanes, thermal insulation, and acoustics linings fitted and properly secured
3. VISUAL CHECK FOR AIR TIGHTNESS

CHECKED

- Seating of filter and washer cells
- Plantroom door seals around entire periphery
- Inspection covers fitted
- Water seals filled
- Builders’ work ducts and shafts sealed
- Ductwork joints, including flexible couplings
- Presence of plugs or covers for test holes

4. FANS

Check and record the following

- External cleanliness
- Anti-vibration mountings and fixings
- Level or plumb of fan and motor shaft and slide rails

Correct drive fitted

- Securing of pulleys
- Belt tension, matchings, and absence of distortion due to prolonged pretension
- Impeller secured, free to rotate, of correct handling, and in static balance
- Guards on with access for speed measurement of fan and motor

Bearing cleanliness

- Fresh and correct grade of lubricant
- Bearing coolant

All components, bolts, fixings, etc, secure
Axial flow type fans installed for correct air flow direction and in correct order if compounded
5. ELECTRICAL

Check and record the following:

Isolate all supplies and check:

Power and control wiring complete and correct, local isolation provided

Starters, ammeter ranges, and overload fuses relevant to motor circuitry and supply as given by motor plate

Overload settings, dashpots charged with correct fluid relative to ambient temperature

Setting of timers

Reduced voltage selection, such as transformer taps, etc

Correct motor fitted

Motor clean, bearings lubricated, and all airways clear

Looped or flexible electrical connections fitted and secured on motionless side of any anti-vibration mounting

Next, connect to supply and check:

Declared voltage available on all supply phases

In the case of large motors or complex circuitry starter operation sequence, timers and safety interlocks checked with the prime movers disconnected
SUBJECT COMPLETION OF SUBCONTRACT WORK

PART C1.5 SECTION 22 PAGE 1 OF 1

1. GENERAL

Completion of the works will occur after the following procedure has been certified by the Architect as having been carried out in accordance with the specification:

1.1. After the defects are made good and approval of the Engineer is obtained, physical completion has been reported to the Architect by the Subcontractor and the Architect has given approval for "start-up".

1.2. "Start-up" has taken place.

1.3. Commissioning and testing has taken place as specified and test results have been witnessed (where required), recorded and finally approved by the Architect.

1.4. Two sets of "as built" drawings, on plastic foil, and approved by the Engineer, have been furnished to the Architect and the Engineer.

1.5. Five copies of indexed loose leaf manuals containing complete Operating Instructions and Maintenance Manuals have been furnished to the Architect after approval by the Engineer, for all mechanical and electrical systems, equipment and controls, and for all other equipment or systems specified under this subcontract. The Operating Instructions and Maintenance Manuals shall be as set out and described in Part C1.5 Section 18.
PART C2
PRICING DATA
1. GENERAL

1.1 These Bills of Quantities contain pages numbered consecutively in each bill as indicated in the Master Index. Before the tenderer submits his tender he should check the number of pages, and if any are missing or duplicated or the figures or writing indistinct, or the Bills of Quantities contain any obvious errors, he should apply to the enquirer at once and have same rectified, as no liability whatsoever will be admitted by the enquirer in respect of errors in tender due to foregoing.

1.2 The Bills of Quantities form part of and must be read in conjunction with the specifications and drawings which contain the full description of the work to be done and material and equipment to be used.

1.3 Tenders shall be submitted for initial consideration on the declaration of the total value of the bills, Bill Summary, Non Scheduled Bill Item Rates and Extra over Rates. Subject to declaration of intent to enter into a contract, the bills priced in detail shall be made available within 4 working days after the request to submit the completed bill.

The enquirer may request the submission of completed bills by more than one tenderer subsequent to the tender opening where special circumstances warrant this request.

1.4 The total sum in the tender form or other sum, subsequently negotiated between the enquirer and tenderer shall constitute the contract sum of the successful tenderer. Tenderers are advised to check their item extensions and total additions, as no claim for arithmetical errors will be considered.

1.5 No alteration, erasure or addition is to be made in the text of the Bills of Quantities. Should any alteration, erasure or addition be made and included in the contract Bills of Quantities; it will not be recognized or accepted and the original wording; prior to the unauthorized alteration, erasure or addition; of the tender Bills of Quantities will supersede and be adhered to.

1.6 The tenderer will receive the Bills of Quantities in a .pdf format as well as a .xlsx format. The Microsoft Excel version may be used by the tenderer strictly for rate capturing purposes only. The rate column is also protected and is a summation of the converted foreign price and local price. In the event of a line item having a foreign price component; the currency, foreign price and exchange rate needs to be captured for each line item. Tenderers can provide for their profit in the local price column together with any other local price components.

Figure 1: The .xlsx Bill of Quantities column layout

1.7 The priced Bills of Quantities of the successful tenderer will be checked and the enquirer reserves the right to call for reasonable adjustments to any individual price and to rectify any discrepancy whilst the total tender price, as submitted, remains unaltered. Rectifications would entail that calculations need to be done in reverse resulting in the item rate(s) being altered to resolve discrepancies. Should the tenderer wish to withdraw his tender as a result of the rectifications, the tenderer may do so in writing. All discrepancies need to be resolved before award of the contract.

1.8 The responsibility for the accuracy of the quantities written into the bills remains with the party who prepared the bills. The tenderer shall be relieved of responsibility of measuring quantities at the tender stage, and tender sum submitted shall be in respect of the quantities set out in the bills, although he will be required to make his assessment of items such as fixings, etc. from details stated in the bills and shall include in the item prices for such small installation materials as are required for the complete installation in accordance with the specification.

1.9 The Subcontractor and the Employer or his Agent may agree that the total of any bill or bills, including any changes by way of additions thereto or deductions therefrom, represents a fair and accurate qualification of the items set out in the bills and the parties may agree final payment on that basis. In the event of any dispute as to the quantities, then the disputed item or items shall be adjusted where necessary.
1.10 The quantities in these Bills of Quantities are not to be used for ordering purposes.

1.11 Changes in the scope and extent of the work included in the Bills shall be allowed to meet the Employer’s requirements.

1.12 Unless separate rates for the supply and for the installation of any item are specifically called for, the supply and installation costs of any item shall be fully included in the unit price.

The description and pricing of each item shall, unless otherwise stated herein, be held to include making, conveying and delivering, unloading, unpacking, setting, fitting and fixing in position, cutting and waste, patterns, templates, plant, return of packings, profit and all other obligations arising out of the conditions of contract, excluding preliminaries.

Craneage and hoisting should be listed separately.

1.13 The labour and transport rates and the overhead and profit percentage included for Non-Scheduled Bill Items in the tender shall form part of the contract.

1.14 Tenderers shall price the Preliminaries under any or all of three groups, viz:

1.14.1 a fixed amount;
1.14.2 a value related amount - an amount varied in proportion to the final contract value as compared to the tender price;
1.14.3 a time related amount - an amount varied in proportion to the final contract period as compared to the originally specified contract period.

The allocation of prices to the three categories listed above must be realistic and the Subcontractor may be required to justify the allocation of the prices. Attention is particularly drawn to the right reserved in terms of Clause 1.6 above.

1.15 Any work for which a budgetary allowance has been made, shall be priced in terms of the n/s agreement. Any balance remaining shall be deducted from the budgetary allowance in the n/s contract sum.

1.16 The quantities in these Bills of Quantities are measured provisionally. All work executed in accordance with the workshop drawings approved by the Engineer shall be re-measured by the agent who measured the original Bill of Quantities and priced at rates contained in, or based on, the priced Bill of Quantities.

1.17 Provision is made on the Tender Form for the applicable Value Added Tax to be added.

1.18 Monthly progress claims may be based on the percentage completion of the items under the main headings.

1.19 Where escalation is calculated in terms of the JBCC formula all non-scheduled item prices must be de-escalated to the base date.

Alternatively the non-scheduled item could be treated as a proven cost item.

2. **METHOD OF MEASUREMENT**

2.1 **RECTANGULAR DUCTWORK**

2.1.1 Rectangular ductwork, including bends and fittings will be measured along the centre lines and will be billed in square meter according to size in the five categories based on the SARACCA classification (See Table A for SARACCA Classification).

2.1.2 Construction methods to be in terms of SMACNA standards.

2.1.3 Where an in-line reduction in size of ducting occurs, the larger size shall be measured over the full length of the fitting. Bends will be measured along perpendicular centre lines and will be billed as extra over to allow for the additional labour, vanes, etc. based on number on the SARACCA classification. All bends in a particular category will be grouped together, irrespective of the change in direction.

2.1.4 A T-piece will be made up of two bends; one in each direction of the split. A T-piece will therefore be measured
as two bends, each based on its branch duct size.

2.1.5 Special fittings, such as trouser pieces, and off-centre off sets and square to rounds to be billed individually as extra over with detailed descriptions to allow for the additional labour to manufacture and erect.

2.1.6 The enquirer is to list the ductwork and fittings in terms of the above. The extra over rate is not applicable in this instance.

2.1.7 The rate for ductwork shall include all necessary jointing materials such as drive-slips, slip joints, angle section flanges, gaskets, nuts, bolts, duct sealer etc. and shall allow for off-cuts and wastage.

2.1.8 Duct supports shall be measured in the duct rate and shall include fixing to concrete slabs, roof trusses and purlins as required.

2.1.9 Distinction shall be made between ductwork fixed vertically or horizontally and between ductwork fixed to different elements and at different heights, if specified as such in the Bills of Quantities. By default the tenderer shall assume that no special fixing methods are required, unless specified differently in the Bills of Quantities.

2.1.10 Special ductwork such as high pressure ductwork and kitchen canopy exhaust ductwork, shall be billed separately in detail.

2.2 ROUND DUCTWORK

2.2.1 Straight round ducts shall be listed in meters.

2.2.2 Round fittings shall be listed separately by type as well as size and shall be listed in number.

2.2.3 The rate for ductwork shall include all necessary jointing materials such as slip joints, angle section flanges, gaskets, nuts, bolts, duct sealer etc. and shall allow for off-cuts and wastage.

2.2.4 Duct supports shall be measured in the duct rate and shall include fixing to concrete slabs, roof trusses and purlins as required.

2.2.5 Distinction shall be made between ductwork fixed vertically or horizontally and between ductwork fixed to different elements and at different heights, if specified as such in the Bills of Quantities. By default the tenderer shall assume that no special fixing methods are required, unless specified differently in the Bills of Quantities.

2.2.6 Flexible ductwork shall be billed in meters and number of lengths based on a length of 1½m (expanded) per section. The rate shall include for two clamps per 1½m section.

2.3 DUCT INSULATION

2.3.1 Internal insulation shall be listed in square meters based on the nett metal surface area of the duct to which the insulation is applied based on the measurement method in 2.1.

2.3.2 External insulation shall be listed in square meters based on the outside surface area of the insulation.

2.3.3 Rates for insulation shall include glue for fixing and pins as per specification.

2.3.4 Areas for different types of insulation and different thicknesses to be listed separately.

2.4 PIPING AND TUBING

2.4.1 Piping and tubing shall be measured in meters, stating the internal or external diameter in accordance with accepted trade usage. The rate for piping shall include cutting, jointing and running joints. The lengths of pipes shall be measured over/through all fittings but not over valves, pumps and inline instruments such as strainers, site glasses, etc.
2.4.2 Pipe fittings shall be billed “in number” as “extra over” piping. Pipe fittings such as bushes, elbows, bends, tees, junctions, etc. to pipes not exceeding 50mm diameter shall be given in one item for each diameter of pipe. Pipe fittings to pipes exceeding 50mm diameter shall be given separately for each diameter of pipe and each type of fitting. Unions, valves, flanges, etc. shall be given separately for all diameter of pipe. Purpose-made fittings are to include for lining up of fittings.

2.4.3 The rate for a pair of flanges shall include for flange weld, gasketing and bolts.

2.4.5 Pipe supports shall be measured in the pipe rate and shall include fixing to concrete and roof trusses.

2.4.6 Where anti-vibration elements are to be used with the supports, these elements to be listed separately.

2.4.7 Refrigerant charge for piping and equipment shall not be included in the pipe rate, but shall be billed separately in kg.

2.4.8 Black piping and galvanized piping and their respective fittings to be billed separately.

2.5 PIPE INSULATION

2.5.1 Pipe insulation shall be measured in meters stating the diameter of the pipe. Pipe fittings shall be billed in number as “extra over” pipe insulation, all as described under 2.4 piping above.

2.5.2 Where cladding to insulation is required, this is to be listed separately.

2.6 FANS AND ATTENUATORS

2.6.1 Prices for fan assemblies shall include support from structure, connection to ductwork and vibration isolation mountings.

2.6.2 Sound attenuators, venturi discharges, flexible connections and inspection doors shall be billed separately.

2.7 DIFFUSERS, GRILLES, LOUVRES, DAMPERS ETC.

2.7.1 Diffusers, grilles, louvres, dampers, fire dampers, filters, etc. shall be given in number for the different sizes.

2.7.2 Master and slave variable volume diffusers shall be billed separately.

2.7.3 Any special finishes to be identified clearly. “Finish to architects’ approval” not acceptable.

2.8 SUPPORTS

2.8.1 Rates for pipework, ductwork and fans to allow for “normal” supports.

2.8.2 Where additional supports between roof trusses and purlins are required or where stands for fans have to be provided, then these supports shall be listed separately and measured as an extra over item.

2.9 SPARES AND REPLACEMENTS

2.9.1 Any spares to be billed separately in detail.

2.9.2 Filter panels and other elements to be replaced during the guarantee period to be billed separately.

2.9.3 Chemicals for the flushing of water systems to be listed.
2.9.4 Water treatment chemicals to be purchased directly by the employer from the supplier from the date of practical completion. Price for chemicals to be requested at time of tender.

2.10 GENERAL ITEMS

The following items should be included in the preliminaries under the special conditions (refer to C1.5).

2.10.1 Testing and commissioning;
2.10.2 12 Month guarantee and maintenance;
2.10.3 Rigging and crane hire;
2.10.4 Labels;
2.10.5 etc.

3. PRELIMINARIES

Refer JBCC Preliminaries (code 2103).
### Table A: SARACCA

**Revised Low Pressure Duct Metal Thickness**

**Classification:** Positive Pressure: 500 Pa  
Negative Pressure: 500 Pa  
**Velocity:** 10 m/s

<table>
<thead>
<tr>
<th>Category</th>
<th>Longest Side L/S mm</th>
<th>Semi Perimeter mm</th>
<th>Minimum Thickness mm</th>
<th>Maximum Spacing Between Joint mm</th>
<th>Maximum Spacing Between Stiffener mm</th>
<th>Joint Type</th>
<th>Type of Intermediate Stiffener</th>
<th>Maximum Spacing Between Hangers mm</th>
<th>Hanger Rod Dia mm</th>
<th>Hanger Angle mm</th>
<th>Measured Sheet Metal Mass kg/m²</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Up to 750</td>
<td>&lt;1149</td>
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<td>2400</td>
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<td>Note 1</td>
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<td>Note 3</td>
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**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 and Flanges**  
   - Up to 1350mm - 25mm flange, 1351 - 2100mm 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).
PART C2.3
PRICED BILL OF QUANTITIES
**Section C: Special Conditions of Contract Agreement**

*(Refer to Part IIIa)*

1.1 **Section 01: Definitions and Abbreviations**
   (F:.............. / V:.............. / T:.............. )

1.2 **Section 02: General**
   (F:.............. / V:.............. / T:.............. )

1.3 **Section 03: Drawings and Submissions**
   (F:.............. / V:.............. / T:.............. )

1.4 **Section 04: Work provided by Others**
   (F:.............. / V:.............. / T:.............. )

1.5 **Section 05: Compliance with Standards and Regulations**
   (F:.............. / V:.............. / T:.............. )

1.6 **Section 06: Safety**
   (F:.............. / V:.............. / T:.............. )

1.7 **Section 07: Hoisting and Rigging**
   (F:.............. / V:.............. / T:.............. )

1.8 **Section 08: Section Omitted**
   (F:.............. / V:.............. / T:.............. )

1.9 **Section 09: Programming**
   (F:.............. / V:.............. / T:.............. )

1.10 **Section 10: Contract Management**
    (F:.............. / V:.............. / T:.............. )

1.11 **Section 11: Organization and Staff of Subcontractor**
    (F:.............. / V:.............. / T:.............. )

1.12 **Section 12: Protection Against Damage**
    (F:.............. / V:.............. / T:.............. )

1.13 **Section 13: Access to Equipment and Systems**
    (F:.............. / V:.............. / T:.............. )

1.14 **Section 14: Cleaning and Start-up**
    (F:.............. / V:.............. / T:.............. )

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Carried Forward

Bill No. 1
Preliminaries
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<td>Section 16: Guarantee (F:............... / V:............... / T:............... )</td>
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<td>Section 17: Quality Management System, Testing and Inspection (F:............... / V:............... / T:............... )</td>
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<td>Section 18: Operating and Maintenance Manuals (F:............... / V:............... / T:............... )</td>
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<td>Section 19: One Year's Maintenance (F:............... / V:............... / T:............... )</td>
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<td>Section 20: Special Attendance (F:............... / V:............... / T:............... )</td>
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<td>Section 21: Preparation of Pre-Start up Checklist (F:............... / V:............... / T:............... )</td>
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<td>Section 22: Completion of Subcontract work (F:............... / V:............... / T:............... )</td>
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**SUMMARY OF CATEGORIES**

- Category: Fixed R.................................
- Category: Value R.................................
- Category: Time R.................................

1.23 Total preliminaries cost

---

**Brought Forward**

- Total preliminaries cost

---

**Carried to Summary**

Bill No. 1 Preliminaries
### Ducting

**Galvanised sheet metal ducting and fittings including supports and fixings (refer to Part C.3 Section 09.01)**

**Galvanised sheet metal ducting supported in single volume space**

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**Galvanised sheet metal ducting supported in riser shafts**

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**Extra over for fittings (bends, transformations, stop ends, shoes, square to rounds, take-offs, offsets) (refer to Part C.3 Section 09.01 & Part C.3 Section 18.05.02)**

**Galvanised sheet metal ducting bends**

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**Bill No. 2**

**Ducting**
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Bill No. 2
Ducting

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**Bill No. 2**

**Ducting**
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**Duct insulation**

External duct insulation (Refer to Part IV Section 04 for specifications)

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**Carried to Summary**

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<td>Refrigerant Piping</td>
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<td>Refrigerant piping (TENDERER TO MEASURE, reticulation as per cable trays)</td>
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<td>Refrigerant piping lagging (TENDERER TO MEASURE, reticulation as per cable trays)</td>
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<td>Refrigerant cable tray mounting type: single</td>
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<td>200mm Perforated metal cable tray</td>
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<td>400mm Perforated metal cable tray</td>
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<td>900mm Perforated metal cable tray</td>
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<td>Extra over for supply, deliver and installation of heavy duty cable tray bends</td>
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<td>400mm Perforated metal cable tray bend</td>
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Carried to Summary

Bill No. 3
Piping
## Terminals

**Constant volume terminals (refer to Part C.3 Sections 15.02.01-15.02.03)**

### Supply air grilles

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<td>SAG, 250mm × 250mm c/w OBD, SG03</td>
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<td>SAG, 700mm × 300mm c/w OBD, SG01</td>
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### Return & extract air grilles

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<td>RAG, 150mm × 150mm, c/w OBD, EG02</td>
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<td>RAG, 710mm × 400mm, c/w OBD, EG01</td>
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### Extract & supply disc valves

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### CAV Ceiling mounted diffusers

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**Bill No. 4
Terminals**
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Carried to Summary

Bill No. 4
Terminals

PRM-MAS-BIL-QUA-04 (Mar 2018)
## Equipment

**Variable Refrigerant Flow (VRF) units (refer to Part C.3 Section 14.06 for specification)**

VRF UNITS Supply and Installation of Heat Recovery VRF system as per specification Part C.3 section 14.6:
- INCLUDING: - insulated refrigerant pipe & connections between indoor and outdoor unit in GMS trunking (refer to drawings for pipe lengths and position of equipment) - indoor & outdoor units - 12 months maintenance and guarantee - project management, engineering of system - overall commissioning - drain pipe connections - electrical wire of indoor & outdoor - low ambient kit, wired control - wired wall mounted control for meeting rooms only (the rest of the areas to have a temperature sensor and be controlled via central controller or BMS) - Relevant refrigerant accessories as per supplier - Relevant refrigerant accessories as per supplier - wire basket for refrigerant piping

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<td>5.11</td>
<td>VRF cassette units, VRFCU-03, 6.80 kW</td>
<td>No</td>
<td>6</td>
<td></td>
<td></td>
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</table>

**Carried Forward**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
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<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
</table>

<p>| Bill No. 5 Equipment | | | | | |</p>
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Brought Forward</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5.12</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-01-GF-S, 56.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.13</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-02-B1, 78.50 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.14</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-02-GF-N, 78.50 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.15</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-03-FF-S, 101.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.16</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-04-SF-N, 112.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.17</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-04-GF-AUD, 112.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.18</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-05-FF-N, 124.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.19</td>
<td>Heat recovery VRF outdoor condenser units, VFROU-05-SF-S, 124.00 kW</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>**Extra refrigerant charge required over and above base refrigerant charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>supplied with unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.20</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-01-GF-S</td>
<td></td>
<td>No</td>
<td>1.00</td>
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</tr>
<tr>
<td>5.21</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-02-B1</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.22</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-02-GF-N</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.23</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-03-FF-S</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.24</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-03-SF-N</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.25</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-04-GF-AUD</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5.26</td>
<td>Extra R410A refrigerant charge for outdoor unit VFROU-05-FF-N</td>
<td></td>
<td>No</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Carried Forward</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bill No. 5
Equipment
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.27</td>
<td>Extra R410A refrigerant charge for outdoor unit VFRDU-05-SF-S</td>
<td>No</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control cabling between VRF outdoor and associated indoor units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.28</td>
<td>Control cabling between outdoor and indoor units (TENDERER to MEASURE)</td>
<td>m</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Carried to Summary**

Bill No. 5
Equipment

Amount
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>ME_Master Control Unit</td>
<td>No</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>ME_Thermostat</td>
<td>No</td>
<td>105.00</td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>ME_VRF Refrigerant Control Box_8Port (Quantity vary between suppliers TENDERER to MEASURE)</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Carried to Summary

Bill No. 6
VRF System Control
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Electrical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variable speed drives (refer to Part C.3 Section 09.05.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: VSD's for installation on existing evaporative units. The VSD must be IP54 rated. Using an IP20 rated drive in a IP54 enclosure is not acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>VSD, 1.00 kW, VSD02</td>
<td>No</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Site wiring and wireways to field equipment including supports and terminations at the field equipment**

Refer to Part C.3 Section 09.05.01

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>VSD, 1.00 kW, VSD02</td>
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<td>4.00</td>
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**Carried to Summary**

Bill No. 7
Electrical
### Existing HVAC Equipment

**Strip Out of the indicated existing fresh air ducting and split units**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
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<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Basement 1 (TENDERER to MEASURE)</td>
<td>SUM</td>
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<td></td>
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</tr>
<tr>
<td>8.2</td>
<td>Ground Floor (TENDERER to MEASURE)</td>
<td>SUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.3</td>
<td>First Floor (TENDERER to MEASURE)</td>
<td>SUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.4</td>
<td>Second Floor (TENDERER to MEASURE)</td>
<td>SUM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Existing Equipment Re-commissioning

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Qty</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>Evaporative Units Re-commissioning</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>8.6</td>
<td>Basement level extract system</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8.7</td>
<td>Ground level toilet extract system</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8.8</td>
<td>First floor toilet extract system</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8.9</td>
<td>Second floor toilet extract system</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Carried to Summary

Bill No. 8
Existing HVAC Equipment
**Prime Cost Amounts**

"Prime Cost Amount" means an amount included in the contract sum for the delivered cost of materials and goods obtained from a Supplier as instructed by the Principal Agent.

Prime Cost Amounts exclude the cost of Overheads, Preliminaries and Profit

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>BMS System</td>
<td>Item</td>
<td></td>
<td></td>
<td>R380,000.00</td>
</tr>
<tr>
<td>9.2</td>
<td>Hot Water System</td>
<td>Item</td>
<td></td>
<td></td>
<td>R93,000.00</td>
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Carried to Summary

Bill No. 9
Prime Cost Amounts
<table>
<thead>
<tr>
<th>Item</th>
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<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td><strong>Design Development</strong></td>
<td>Item</td>
<td>1.00</td>
<td>465,000</td>
<td>465,000</td>
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<td></td>
<td>Allow the amount of R465 000 for future design development.</td>
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<td></td>
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<tr>
<td>10.2</td>
<td><strong>Builders Work</strong></td>
<td>Item</td>
<td>1.00</td>
<td>280,000</td>
<td>280,000</td>
</tr>
<tr>
<td></td>
<td>Allow the amount of R280 000 for the necessary builders work to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>complete the HVAC installation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3</td>
<td><strong>Ceiling Replacement</strong></td>
<td>Item</td>
<td>1.00</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td></td>
<td>Allow the amount of R300 000 for the replacement of ceilings after</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC installation is complete.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.4</td>
<td><strong>Condensate Drain Piping Installation</strong></td>
<td>Item</td>
<td>1.00</td>
<td>165,000</td>
<td>165,000</td>
</tr>
<tr>
<td></td>
<td>Allow the amount of R165 000 for the supply and install of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>condensate drain piping</td>
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**Carried to Summary**

Bill No. 10
Budgetary Allowance
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<tr>
<td>1</td>
<td>Preliminaries</td>
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<td>2</td>
<td>Ducting</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Piping</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Terminals</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Equipment</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>VRF System Control</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Electrical</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Existing HVAC Equipment</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Prime Cost Amounts</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Budgetary Allowance</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

**Total Transferred to Form of Tender**
PART C3

SCOPE OF WORK
1 GENERAL DESCRIPTION OF PROJECT

1. THE COMPLEX

The project is a refurbishment of the existing DBSA Core building for Development Bank of South Africa, the building is located in Midrand Johannesburg. The building is currently fitted with an Evaporative cooling VAV system.

The building consists of the following levels:

- Basement Level (Office, archives and plant rooms)
- Ground Floor (Offices and Meeting Rooms)
- First Floor (Offices and Meeting Rooms)
- Second Floor (Offices and Meeting Rooms)
- Roof Level

2. SCOPE OF WORK

The scope of work is as follows:

a) Strip out of identified sections of the existing supply air ducting including:
   - Supply air ducting on Basement 1, Ground Floor, First Floor and on the South half of second floor,
   - Second fix on Basement 1, Ground Floor, First Floor and on the South half of second floor,
   - Split units on Basement 1, Ground Floor, First Floor and on the South half of second floor,

b) Install new HVAC system including:
   - Fresh air system,
   - VRF System with central controller and
   - Variable speed drives on the existing evaporative cooling units.

c) Install new BMS system including:
   - BMS Front End,
   - Indoor space temperature monitoring and control
   - VRF system communication.

d) Re-commissioning of existing systems including:
   - Toilet extract system on all levels,
   - Evaporative units on the roof and
   - Fresh air system in the basement level.

3. THE AIR CONDITIONING SYSTEM

3.1. Cooling System

3.1.1. Variable Refrigerant Flow (VRF System)

The selected HVAC system for the DBSA Core building is a Variable Refrigerant Flow System (VRF).

Each floor will be served by two outdoor condensing units, the ground floor however will have another additional outdoor unit serving the Auditorium area. The outdoor units will all have heat recovery to allow for simultaneous heating and cooling between the units. Air conditioning to all the floor will be provided by means of ducted hideaway and cassette variable refrigent flow indoor units.

3.1.2. Fresh Air/ Outside Air

The evaporative units on the roof of the building will supply fresh air to the office floors. Fresh air will be supplied directly into the space through Constant Volume Diffusers and in some cases the fresh air will be supplied to the intake of a hideaway unit from
where the unit will supply the fresh air into the space. A balancing damper will be used to make sure that the correct amount of fresh air is supplied to each diffuser/indoor unit (where applicable).

The evaporative units will be provided with variable speed drives to allow for air volume control depending on the installation progress and fresh air requirements on the various office floors.

3.1.3. Controls

The indoor air temperature is controlled through a wall-mounted setpoint adjuster that allows occupants to adjust the desired temperature setpoint.

A central control system will be provided for the VRF installation, with the following functions:
- System scheduling and automatic on/off
- Group management and setting of indoor units
- Control of all indoor and outdoor units
- Systems diagnosis and error identification

4. VENTILATION SYSTEMS

The existing extract systems will remain as is. The extract systems will however be recommissioned to comply with building regulations.

5. DESIGN CONDITIONS

4.1 Weather Data

Altitude above sea level : 1322m
Summer design conditions : 31.1°Cdb / 21.1°Cwb
Winter design conditions : 0.1°C

4.2 Internal Comfort Design Conditions

Max summer temperature : 24°C
Min winter temperature : 20°C
Relative Humidity : Not controlled – Typically between 30 and 60%
Minimum fresh air supply : 2ACH
Internal noise level : NC 40
Occupancy density : Varies
The equipment and/or sub-system supplier/assembler shall provide under the overall responsibility and control of the HVAC Subcontractor, all permanently installed instrumentation necessary for logging and monitoring of status and performance of equipment and components.

In addition, a hand held digital electric instrument, measuring temperature and humidity shall be provided at handover for use by the Employer.

All instruments shall be of such dimensions and mounted in position so that they are easily and accurately readable by an operator standing on the floor.

Test instruments shall be checked for accuracy by the manufacturer or by an approved laboratory with certificates being submitted prior to site tests, showing the degree of accuracy.

1 TEMPERATURE INDICATION

1.1 All direct reading thermometers and temperature reading devices shall have an accuracy of 0.5°C and a range of -10°C to 50°C, unless otherwise specified, with graduation being in steps of 1°C.

1.2 Stem thermometers shall be approximately 150 mm long and dial type thermometers minimum 80mm diameter.

1.3 Wells shall be set vertical or at an angle to retain oil. Pipes smaller than 80 mm bore shall be enlarged at points where wells are installed as per following table:

<table>
<thead>
<tr>
<th>Pipe bore (mm)</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>32</th>
<th>40</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of enlargement (mm)</td>
<td>32</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>65</td>
<td>80</td>
</tr>
</tbody>
</table>

1.4 The sensor element shall be at the centre of the pipe.

2 PRESSURE INDICATION

2.1 All dial pressure gauges shall be glycerine filled to prevent pointer vibration. Gauges shall have an accuracy of 2%. The range shall extend to 150% of the maximum operating pressure.

2.2 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 in steps of 10 Pa.

2.3 All differential dial pressure gauges shall have an accuracy of 2% and shall not be less than 100 mm 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.

2.4 Syphon tubing to pressure gauges must be galvanised and must be insulated.

2.5 Pressure gauges must be installed before and after water strainer.

3 HYGROMETERS

3.1 Hygrometers shall have an accuracy of 5% in the range of 20% to 100% relative humidity.

4 FLOW METERS

4.1 Liquid flow shall be measured by means of an in-line orifice, or Venturi tube and differential pressure gauge normally calibrated in litres per second - 5% accuracy.
All identification shall be legible, and shall be painted or fixed after completion of final finishes. Identification colours shall be in accordance with BS 1710 and/or as instructed or approved by the Architect.

1 SIGHTGLASS/MOISTURE INDICATOR

1.1 A sightglass/moisture indicator shall be installed in the refrigerant circuit of each chiller and/or condensing unit.

1.2 The indicator shall be suitable to read the recommended moisture levels of the refrigerant used.

1.3 The indicator must be after the filter drier and must be visible.

2 LABELS

2.1 A label shall be provided under each gauge, meter, instrument, pilot lamp, remote control switch, motor controller and panel mounted item identifying the equipment controlled and/or performance indication by such items.

2.2 The labels shall consist of a non-corroding material with a non-glossy appearance, engraved with black lettering on a white background. All labels shall slide in a screwed-on type aluminium bracket unless otherwise approved.

3 VALVE TAGS AND CHARTS

3.1 Numbered tags including letters to identify the system, shall be brazed to all valves indicated on the drawings, or be fastened by heavy brass chain to such valves.

3.2 The metal tags shall be 50 mm in diameter and 1 mm thick, and shall have stamped-in number and letters.

3.3 The Subcontractor shall be responsible for submitting a list of all valves and controls, giving location and function, together with diagrammatic charts featuring each piping system with valves and controls, identified by numbers and letters shown on the corresponding tags.

4 DIFFUSERS

4.1 Each diffusers/grille shall be labelled with a unique number which shall be reflected on the as build drawing, drawing asset register and commissioning sheets.

5 PIPING

5.1 In addition to painting of pipes (including insulation), colour coded polyvinyl chloride bands shall be applied to pipes identifying their content and direction of flow.

5.2 Bands shall be provided to piping at valve location, at points where piping enters or leaves a partition, wall, floor or ceiling and at least at every 10 m centres of straight runs. Where piping is concealed, bands shall be applied at valves or other devices whenever access is provided by doors or panels. Exit and entrance points to each vessel, tank or place of equipment shall be identified by bands. Insulated pipes shall be banded after insulation and painting work has been completed.

5.3 The band's width shall be minimum 200 mm wide for pipes up to 250 mm diameter and 400 mm wide for larger diameter piping. The pre-printed letters on band, identifying the service shall be at least 20 mm high.
5.4 Piping of less than 25 mm nominal bore need not be colour banded but shall be painted all over with the identifying colour of its content.

5.5 The flexible hoses serving the access floor and/or ceiling fan coil units shall be colour banded as follows:
- Hoses with "male" part of coupler: "midnight blue"
- Hoses with "female" part of coupler: "light blue"

5.6 Only one band with a minimum width of 20 mm shall be provided around

5.7 Re-insulation on both ends of the hose.

6 DUCTWORK

6.1 All ductwork shall be identified by writing in words the service of the duct and by pointer showing the direction of flow. Markings shall appear at least at the point of origin and whenever ducting enters or leaves walls, floors or ceilings and for every 20 m centres of straight lines.

6.2 The identification letters shall be at least 50 mm high and the flow arrow 150 mm long.

7 ACCESS PANELS

7.1 Approved tile markers shall be provided in areas where removable ceilings or access panels are positioned to indicate the location of valves and/or other devices.

8 COLOUR CODING

8.1 Unless otherwise indicated, the following colour code shall be used:

<table>
<thead>
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### SUBJECT: IDENTIFICATION

#### PART C3.2  SECTION 02  PAGE 3 OF 3

<table>
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<td>20 Shut off valve handles</td>
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<td>22 Liquid line</td>
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<td>26 Toilet ventilation ducts</td>
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<td>27 Air conditioning ducts (return air)</td>
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<td>28 Ventilation ducts</td>
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<td>29 Plenums</td>
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<tr>
<td>1</td>
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<td>2</td>
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</tr>
<tr>
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<td>Light blue</td>
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<tr>
<td>6</td>
<td>Midnight blue</td>
<td>G116P</td>
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<tr>
<td>7</td>
<td>Azure blue</td>
<td>BSF05</td>
</tr>
<tr>
<td>8</td>
<td>Golden yellow</td>
<td>BS49</td>
</tr>
<tr>
<td>9</td>
<td>Signal red</td>
<td>G7P</td>
</tr>
<tr>
<td>10</td>
<td>White</td>
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<td>11</td>
<td>Carrier green</td>
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<td>12</td>
<td>Aluminium numelon code AN</td>
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<td>Eyereast grey</td>
<td>G7P</td>
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<td>Battleship grey</td>
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</tr>
<tr>
<td>15</td>
<td>Beige</td>
<td>BS366</td>
</tr>
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</table>
1 GENERAL REQUIREMENTS

1.1 The requirements of ISO 12944 shall apply as a minimum to all coating application activities. Supplementary requirements are given in this document. In the event of conflict between this document and the ISO standard, the requirements of this document will prevail.

1.2 The sub-contractor shall be responsible for ensuring that the coating manufacturer's instructions, including, but not limited to:

   1.2.1 Surface preparation and cleaning.
   1.2.2 Preparation and application of coating materials.
   1.2.3 Shelf life and storage requirements

are adhered to:

1.3 Only approved coating materials as detailed in the specification shall be used. These shall not be mixed with materials from different manufacturers.

1.4 The sub-contractor shall use experienced labour with qualified supervision and inspection. Applicators and supervisors should preferably be qualified to the South African Qualification and Certification Committee for Corrosion Protection (SAQCC) PA1 and SP1.

1.5 The sub-contractor shall use colours selected by the design team to the SANS 1091 or RAL colour standards.

1.6 The sub-contractor shall ensure that piping and proprietary equipment are adequately protected when stored on site to prevent internal corrosion.

2 GREEN STAR REQUIREMENTS

2.1 Any paint/solvent based coating used for piping, support steelwork and air-conditioning ductwork and equipment must have a VOC content of less than 200 g/l in the 'ready-to-use' product. Where the manufacturer requires solvent additions to the as-supplied product strict instructions are required from the manufacturer in terms of the maximum solvent additions allowed to ensure that the ready-to-use product still meets the 200 g/l limit.

3 SURFACE PREPARATION

3.1 All sharp edges, burrs, rags and weld splatter shall be removed and weld areas shall be abraded and/or ground.

3.2 The surface shall be de-greased and rinsed with solutions supplied by the coating manufacturer prior to mechanical cleaning (clause 4.4 of SANS 10064).

3.3 Surface preparation shall be as specified in accordance with ISO 8501-1 and SANS 10064 and shall be conducted before erection of pipes.
### SUBJECT: PAINTING AND PROTECTION AGAINST CORROSION

#### PART C3.2  SECTION 03  PAGE 2 OF 9

## 4 COATING/PROTECTION SPECIFICATIONS

<table>
<thead>
<tr>
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<th>SPECIFICATIONS/CODES</th>
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<tr>
<td><strong>Protective Coatings</strong></td>
<td>(Refer to Appendix A)</td>
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<tr>
<td>The external protection of insulated chilled water piping.</td>
<td>PCS 01</td>
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<tr>
<td>The external protection of uninsulated steel piping internal and external to buildings in both inland and marine environments and mild steel support structures and black steel kitchen extract ducting internal to buildings in inland and dry environments.</td>
<td>PCS 02</td>
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<tr>
<td>Mild steel support structures to buildings in moist conditions and external to buildings in inland environments.</td>
<td>PCS 03</td>
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<tr>
<td>Mild steel support structures internal and external to buildings in marine environments.</td>
<td>PCS 04</td>
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<thead>
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<tr>
<td><strong>Anti-Corrosive Coatings</strong></td>
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</tr>
<tr>
<td>Air Cooled condenser coils within 35km of the coast or coils where specifically specified</td>
<td>- Salt spray as per ASTM B117 of &gt;5000hrs (corrosion durability)</td>
</tr>
<tr>
<td></td>
<td>- Cross hatch as per ASTM 3359-93 of 5B (adhesion)</td>
</tr>
<tr>
<td></td>
<td>- UV resistance as per ASTM D4587 of 500 hours</td>
</tr>
<tr>
<td></td>
<td>- Heat transfer loss must be less than 1%</td>
</tr>
<tr>
<td></td>
<td>- The coating dry film thickness should be 15-30 microns without material bridging between fins</td>
</tr>
<tr>
<td></td>
<td>- The coating applicator must provide a declaration ROHS (Restriction of Hazardous Substances)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>SPECIFICATIONS/CODES</th>
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<tr>
<td>The external surfaces of galvanised steel ducting internal and external to buildings in both inland and marine environments.</td>
<td>PCS 05</td>
</tr>
<tr>
<td>Electric motors, gearboxes, pumps, valves and other proprietary equipment internal or external to buildings in both inland and marine environments.</td>
<td>PCS 06</td>
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<td><strong>Hot Dip Galvanizing</strong></td>
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</tr>
<tr>
<td>Due cognisance of the type of article and zinc thickness is required.</td>
<td>SANS 121 (ISO 1461) – Hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods</td>
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<thead>
<tr>
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<td><strong>Powder Coatings</strong></td>
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<td>Steel or galvanised components.</td>
<td>SANS 1274 – Type 6</td>
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<td>Architectural aluminium components.</td>
<td>SANS 1578-1</td>
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<td>SANS 1578-2</td>
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<td><strong>ANODIZING OF ALUMINIUM</strong></td>
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<tr>
<td>Architectural components</td>
<td>SANS 999</td>
</tr>
<tr>
<td>General purpose aluminium articles</td>
<td>SANS 1407</td>
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</table>
4.1 Should the applicator or manufacturer wish to propose alternative products or coating materials, he shall submit a detailed motivation to Spoormaker & Partners. The motivation shall include, but not be limited to the following:

4.1.1 Benefit to the Client
4.1.2 Product licensor and technical back-up available;
4.1.3 Location, experience and ISO quality rating of the production facility;
4.1.4 Detailed case histories;
4.1.5 Performance guarantee offered;
4.1.6 Manufacturer’s data sheets for each product.
4.1.7 Confirmation that the coatings meet the specified VOC requirements.

5 COATING APPLICATION

5.1 The sub-contractor shall submit a Quality Plan for approval prior to the commencement of any coating work.

5.2 The coating application work shall be carried out in strict accordance with the most recent Product Data Sheet from the coating manufacturer.

5.3 The product data sheet shall be deemed to be part of this specification.

5.4 Coatings shall not be applied when surface may become damaged due to rain, dust, condensation, surface temp (>30°C) or excessive humidity (>85%).

5.5 All surfaces shall be coated as specified. Successive coats shall be of distinctly different colour to the previous coat to ensure correct inter coat coverage. Special attention shall be given to cracks, crevices and edges to ensure complete coverage and paint thickness.

5.6 The primer shall be applied as soon as possible after the surface preparation operation, but within 4 hours.

5.7 Concealed surfaces shall be completely coated.

5.8 All edges, corners, welded joints, flanges, bolt holes and cut ends shall be stripe coated by brush application, prior to the application of the second coat.

5.9 No coating shall be applied to any surface containing traces of grit, grease, soil, loose rust, surface contaminants (i.e. dust) or loose corrosion product of any kind.

5.10 Surface rust on steelwork shall not exceed Grade B of ISO 8501-1.

5.11 Coating that was applied excessively which shows marks of wet running paint or poor workmanship must be sanded down and re-painted.

6 PATCH REPAIR PROCEDURE

6.1 Following transport and erection, all areas of coating damage shall be patch repaired by brush application to reinstate the original specified system.

6.2 The extent of the damage shall be carefully inspected to assess which coats in the system have been damaged.
6.3 When the damage extends to the steel substrate, all coats in the system shall be re-instated. Areas to be primed shall be cleaned of dust, dirt, grease or other deleterious matter and mechanically cleaned to grade St 3 of ISO 8501/1.

6.4 All edges of existing coatings shall be feathered back to a hard edge. The patch primer used shall be in accordance with the requirements of the relevant coating system.

7 FASTENERS

7.1 All nuts and bolts shall be either hot dip galvanised or stainless steel unless otherwise specified.

7.2 All galvanised nuts and bolts shall be de greased, patch primed and finish coated in accordance with the specification for the respective area of the plant.

7.3 Washers shall be fitted to each nut and bolt.

7.4 A minimum of two full threads of the bolt must be visible behind the nut once tightened.

7.5 Bolt protrusion behind nut shall not exceed 25mm once tightened.

7.6 Threaded hanger rod ends shall not protrude more than 25mm below the bottom of the support bracket.

7.7 Support brackets shall be coated to PCS 02. Any damage to the bracket coatings during installation shall be repaired in accordance with the PATCH REPAIR PROCEDURE.

7.8 If the galvanized threaded hanger rods are damaged or cut during installation the damaged zinc coating shall repaired in accordance with SANS 121 (ISO 1461) by means of epoxy zinc rich paint. The zinc rich paint shall contain a minimum of 80% zinc in the dry film and the thickness shall be 30 micron greater than the specified galvanizing zinc thickness. The damaged area shall be thoroughly cleaned and the repair coating shall overlap onto the surrounding sound zinc for a distance of at least 25 mm.

7.9 The zinc rich paint for repairs shall be as recommended by the HDGASA, i.e. either Zincfix (Speccoats) or Galvpatch (Drivelines and Sprayflow cc).

7.10 The use of aerosol spray repair coatings is not permitted.

8 THE PREVENTION OF GALVANIC CORROSION

8.1 Care must be taken to prevent or mitigate the corrosion caused by dissimilar metal contact on cooling coils, tubes and tube plates, pipes, flanges, frames etc. Typical metals encountered would be copper, aluminium, zinc, mild steel and stainless steel.

8.2 The junctions between dissimilar metals must be electrically insulated where possible.

8.3 Pipe flanges between dissimilar metals must be insulated using insulating gaskets for the flange faces and insulating sleeves and washers for all nuts and bolts.

8.4 Where the insulation of the junction between dissimilar metals is not practical, the cathode surface on the electrolyte or ‘wet’ side must be coated for a minimum distance of 100 mm from the junction. The applied coating must effectively isolate the coated surface from the electrolyte.
9 INSPECTIONS AND TESTING

9.1 The sub-contractor shall have the necessary equipment and qualified staff to carry out the quality control required to ensure compliance with the specification. The coating inspector shall preferably be qualified to either the South African Qualification and Certification Committee for Corrosion Protection (SAQCC) Level 1 or NACE CIP Level 1.

9.2 The following inspections and tests shall be performed by the sub-contractor and witnessed by the design team in accordance with the approved Quality Plan on corrosion protection.

9.3 Visual inspection for paint film defects shall be performed after each coat is applied. All defects including pinholes, sags and runs shall be corrected before the next full coat is applied.

9.4 Painted surface must be continuous, smooth and uniform

10 DRY FILM THICKNESS

10.1 Dry film thickness shall be measured in accordance with ISO 2808:1967. Instrument calibration shall be on the smooth calibration disc provided by the instrument manufacturer.

10.2 The required dry film thickness is given in recommended 'windows' for each coat in the relevant coating specification, i.e. required minimum and acceptable maximum. As the various brand coatings are being guaranteed by the respective coating manufacturers, the minimum and maximum thickness requirements must be as specified in the relevant manufacturer’s Product Data Sheet. Any reading outside the manufacturer’s specified range is cause for rejection and may require the removal of the entire coating and reapplication thereof.

10.3 Actual readings and not averages shall be recorded.

11 QUALITY ASSURANCE

11.1 SUB-CONTRACTOR QUALIFICATION

11.1.1 The design team may, at its discretion, require a Quality Audit of the painting sub-contractor to ensure that he has the management, facilities, skilled staff and quality control facilities and staff, to carry out both the coating application and the required quality control during application of coatings to ensure compliance with specification.

11.1.2 The sub-contractor shall accept full responsibility for the quality of his work and of materials used, irrespective of any quality surveillance that may be carried out by the design team.

11.1.3 The sub-contractor shall keep at least the following records in his QA File on site:

11.1.3.1 Product Data Sheets
11.1.3.2 Material batch records
11.1.3.3 Psychrometric records
11.1.3.4 Records of surface preparation
11.1.3.5 Dry film thickness measurements per coat
11.1.3.6 Copies of inspection reports issued by the coating manufacturer
11.1.3.7 Copies of inspection reports issued by the design team
12 DATA BOOK

12.1 Upon completion of the works, the sub-contractor shall provide Spoormaker & Partners with a Data Book containing all the relevant Quality Control documents and records pertaining to the works.

12.2 This data book shall contain, as a minimum, the following:

12.2.1 The relevant PCS specifications
12.2.2 The Quality Plan
12.2.3 Copies of all Batch Release Certificates from the paint manufacturer
12.2.4 All relevant QC Records listed above
12.2.5 Copies of all design team reports
12.2.6 Copies of all Release Certificates

12.3 The sub-contractor shall keep a copy of the Data Book for his own records.

13 GUARANTEES

13.1 Spoormaker & Partners requires performance guarantees for the applied coating systems. Such guarantees shall be provided jointly by the coating manufacturer and coating applicator. The minimum guarantee period will be 8 years and the criteria for failure will not exceed Ri 3 of ISO 4628-3.

13.2 Although visible coating defects such as blistering, cracking, flaking and peeling are not always associated with visible rusting, they indicate defects that could either lead to substrate corrosion or are shielding substrate corrosion that has already taken place beneath the coating. Any such defects noted during the guarantee period shall be repaired.

13.3 This joint guarantee must be submitted at the time of tender.

13.4 All guarantees in the terms of protection against corrosion shall be ceded to the client.
APPENDIX A
PROTECTIVE COATING SPECIFICATIONS

**SPECIFICATION NO: PCS 01**

**Description:** The external protection of insulated chilled water piping.

<table>
<thead>
<tr>
<th>Supplier</th>
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<th>Primer Coat</th>
<th>Intermediate Coat</th>
<th>Finishing System</th>
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<tr>
<td>International</td>
<td>Degrease Wire brush St 3</td>
<td>Al filled surface tolerant epoxy primer 50 – 125 microns</td>
<td>High build micaceous iron oxide epoxy 75 – 150 microns</td>
<td>Insulation + vapour barrier</td>
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<td>-</td>
<td>Interseal 670HS Aluminium</td>
<td>Intergard 475HS MIO</td>
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<td>Jotun</td>
<td>Degrease Wire brush St 3</td>
<td>Jotamastic 80 Al Std comp B</td>
<td>Penguard Midcoat MIO Red,Grey</td>
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<tr>
<td>Plascon</td>
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<td>Plascon Plasctuff 3000 (PEX3004/PEH 3)</td>
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**SPECIFICATION NO: PCS 02**

**Description:** The external protection of un-insulated steel piping internal and external to buildings in both inland and marine environments and mild steel support structure internal to buildings in inland and dry environments.

<table>
<thead>
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<th>Primer Coat</th>
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<tr>
<td>International</td>
<td>Degrease Wire brush St 3</td>
<td>Al filled surface tolerant epoxy primer 50 – 125 microns</td>
<td>High build micaceous iron oxide epoxy 75 - 150 microns</td>
<td>Water borne acrylic latex 50 – 75 microns</td>
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<td>-</td>
<td>182</td>
<td>Intergard 475HS MIO</td>
<td>Intercryl 700</td>
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<tr>
<td>Jotun</td>
<td>Degrease Wire brush St 3</td>
<td>Jotamastic 80 Al Std comp B</td>
<td>Penguard Midcoat MIO Red,Grey</td>
<td>Waterfine Topcoat Standard shades</td>
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<tr>
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<td>Plascon Plasctuff 3000 (PEX3004/PEH 3)</td>
<td>Plascon Plasctuff 3000 (PEX3004/PEH 3)</td>
<td>Plascon Metalcare WB Enamel (WBE)</td>
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<tr>
<td>Stoncor</td>
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VOC g/l

### SUBJECT: PAINTING AND PROTECTION AGAINST CORROSION

### PART C3.2  SECTION 03  PAGE 7 OF 9
### Subject: Painting and Protection Against Corrosion

#### Part C3.2  Section 03  Page 8 of 9

### Specification No: PCS 03

**Description:** Mild steel support structures internal to buildings in moist condition and external to buildings in inland environments.  
Hot-dip galvanise to SANS 121 (ISO 1461)

### Specification No: PCS 04/PCS 05

**Description PCS 04:** Mild steel support structures internal and external to buildings in marine environments. Galvanise (un-passivated) + duplex coating

**Description PCS 05:** The external surfaces of galvanised steel ducting internal and external to buildings in both inland and marine environments.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Surface Preparation</th>
<th>Primer Coat</th>
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<td>Water borne acrylic latex 50 – 75 microns</td>
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<td>Galvanised Iron Precleaner</td>
<td>Interseal 670HS Aluminium</td>
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<td>15</td>
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<tr>
<td>Jotun</td>
<td>Galvanised Iron Precleaner</td>
<td>Jotamastic 80 Al Std comp B</td>
<td>Waterfine Topcoat Standard shades</td>
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<tr>
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<tr>
<td>Stoncor</td>
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<td>Carboclad 900</td>
<td>Carbocrylic 3350</td>
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</tbody>
</table>
**SPECIFICATION NO: PCS 06**

**Description:** Electric motors, gearboxes, pumps, valves and other proprietary equipment internal and external to buildings in both inland and marine environments. Over manufacturer's standard finish.

**Note:** Conduct an adhesion test on the proprietary coating in accordance with SANS 5159. If the adhesion coefficient is less than 8, return item to manufacturer for replacement. If the adhesion coefficient is 8 or 10, apply upgrade system as above.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Surface Preparation</th>
<th>Primer Coat</th>
<th>Finishing Coat</th>
</tr>
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<tbody>
<tr>
<td><strong>International</strong></td>
<td>St3 Degrease</td>
<td>Epoxy maintenance primer 50 - 125 microns</td>
<td>Water borne acrylic latex 50 – 75 microns</td>
</tr>
<tr>
<td><strong>St3 Degrease</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VOC g/l</strong></td>
<td>-</td>
<td>182</td>
<td>15</td>
</tr>
<tr>
<td><strong>Jotun</strong></td>
<td>St3 Degrease</td>
<td>Jotamastic 80 Al Std comp B</td>
<td>Waterfine Topcoat Standard shades</td>
</tr>
<tr>
<td><strong>VOC g/l</strong></td>
<td>-</td>
<td>145</td>
<td>70</td>
</tr>
<tr>
<td><strong>Plascon</strong></td>
<td>St3 Degrease</td>
<td>Plascon Plascotuff 3000 (PEX3004/PEH 3)</td>
<td>Plascon Metalcare WB Enamel (WBE)</td>
</tr>
<tr>
<td><strong>VOC g/l</strong></td>
<td>-</td>
<td>150</td>
<td>60</td>
</tr>
<tr>
<td><strong>Stoncor</strong></td>
<td>St3 Degrease</td>
<td>Carbomastic 15</td>
<td>Carbocrylic 3350</td>
</tr>
<tr>
<td><strong>VOC g/l</strong></td>
<td>-</td>
<td>88</td>
<td>24</td>
</tr>
</tbody>
</table>
SUBJECT: INSULATION

PART C3.2: SECTION 04 PAGE 1 OF 11

1 GENERAL

1.1 This is a performance specification that requires an equipment submission.

1.2 In case of conflict, this specification takes preference over material and application codes. If the conflict is fire related, the relevant fire code takes preference over this specification.

2 CODES

2.2 Insulation shall be applied as specified in SANS Standards 1238 –2005 and 0173-2003.

3 FIRE

3.1 All thermal and acoustic insulation materials, adhesives, straps and finishes used shall, when tested in accordance with SANS Standard 1238-2005 and BS standard 476, comply with the stated indexes for surface spread of flame, heat contribution, smoke contribution and fire index.

3.2 Material shall be free from substances, which in the event of a fire would generate appreciable quantities of smoke, noxious or toxic fumes.

3.3 Flexible ducting complete with insulation shall be constructed of non-combustible material as required in terms of the building regulations provided that:

3.3.1 Approved combustible flexible connections may be used where the length of such connection does not exceed 1.5m and such connection does not pass through any wall or floor which is required to have a specified fire resistance.

3.3.2 Approved combustible flexible joints not more than 250mm in length may be used in any plant room where such plant room is protected by a smoke detection system.

4 ENVIRONMENTAL

4.1 Insulation materials and finishes shall prevent rotting, mould, fungal growth and attack by vermin, be non-hygroscopic and in all respects to be suitable for continuous use throughout the range of operating temperatures and within the environment indicated.

4.2 Insulation material and their finishes shall be free from any form of asbestos.

4.3 No exposed glass fibre shall be permitted in contact with air.

4.4 The insulation material shall not contain CFC’s and shall be ozone and ultraviolet resistant with an ODP value of ZERO.

4.5 The thermal resistance of the material shall not degenerate below the thermal resistance value quoted over the life span of the product.

4.6 All thermal insulation for pipes and ducts shall have no ozone-depleting substances associated with either the manufacture or composition of the product. Fibre-based woven insulation products (e.g. glass fibre, mineral wool, polyester etc.) and foil insulation are not manufactured using blowing agents may be used.

4.7 The Contractor is to provide written confirmation that all insulation materials installed are as per specification. Contractor is also to provide manufacturer’s data sheets for each insulation product,
SUBJECT: INSULATION

5 QUALITY ASSURANCE

5.1 PIPING

5.1.1 Prior to insulation being fitted, all pressure testing shall be satisfactorily completed. The Specialist Insulation Contractor is, however, allowed to start insulating ductwork before testing provided that all joints are uncovered and visible for inspection.

5.1.2 The HVAC Sub-contractor shall arrange inspections by the Consulting Engineer for the following events:

5.2 PIPING

5.2.1 Samples (For piping, supports, fittings etc. as agreed with the Consulting Engineer)
5.2.2 After paint application to surfaces to be insulated
5.2.3 After second vapour barrier application
5.2.4 Completion of cladding

5.3 DUCTING

5.3.1 Samples (As agreed with the Consulting Engineer)
5.3.2 Finished product

5.4 INSULATION

Insulation shall be stored in a dry and protected environment, and shall be protected after installation. Any materials with signs of physical or moisture damage will be rejected.

6 EQUIPMENT SUBMISSIONS/SAMPLES

6.1 Sample sections of final insulation will be required prior to commencement, as part of the quality control and performance testing.

6.2 An equipment submission shall be submitted for review, containing details on low density insulation on straight pipes runs, high density insulation at pipe supports, insulation for valves, flanges, etc. and insulation for storage vessels. For information required in the equipment submission, refer to Table F.

7 INSULATION MATERIALS/LIFE EXPECTANCY

7.1 The selection of an insulated material shall comply with the manufacturers operating limits for the insulation, including but not limited to criteria for temperature, humidity and compressive strength.

7.2 The materials selected for insulation, vapour barrier and cladding shall be compatible and suitable for the type of application, and shall be galvanic neutral.

7.3 The thickness shall comply as a minimum with the thickness stated in the enclosed table A – E.

7.4 Material selected shall have a median life expectancy of 20 years.

7.5 Insulation materials relying on reflectance and air gaps shall provide certified test results for reflective surface covered with dust and equivalent on site thickness of air gap.

7.6 Materials shall tightly fit the outer perimeter of the medium insulated.

7.7 Acceptable insulation materials for piping:
7.7.1 Pre-formed fibrous insulation sections (minimum density 80kg/m³)
7.7.2 Pre-formed closed cell foam (minimum density 32kg/m³)
7.7.3 Pre-formed closed cell elastomeric (minimum density 48 kg/m³)
7.8 Acceptable insulation materials for pipe fittings:

7.8.1 Fibrous insulation rope with plaster finish
7.8.2 Closed cell elastomeric (min density 48kg/m³)

7.9 Acceptable insulation materials for ducting:

7.9.1 Blanket/sheet glass fibre (minimum density 16kg/m³)
7.9.2 Fire Retardant Polystyrene or equivalent (minimum density 24kg/m³)
7.9.3 Closed cell foam (minimum density 24kg/m³)

8 VAPOUR BARRIER

8.1 The insulation of ductwork, piping and or plant operating below ambient dew point temperature shall be provided with a vapour seal.

8.2 Wherever a vapour seal is discontinued the vapour seal shall be brought back to the surface of the duct, pipe or plant.

8.3 The vapour barrier shall be continuous at pipe supports.

8.4 Wherever a vapour seal is damaged or pierced it shall be sealed with tape of the same material.

8.5 Cold surface insulation relying on closed cell properties of the material for a vapour barrier shall have a minimum moisture resistance value of $\mu > 5000$.

8.6 Acceptable vapour barriers:

8.8.1 Foil Reinforced Kraft (FRK), duct wrap or equivalent, all joints sealed with aluminium tape
8.8.2 Mylar Foil factory fitted and all joints sealed with aluminium tape
8.8.3 Factory fitted PVC and all joints sealed with black tape
8.8.4 Factory fitted Canvass with all joints properly lapped and continuous sealed with canvass material and coated by a polymeric type vapour barrier strictly in accordance with the manufacturers’ recommendation but a minimum of two coats, first a white coat, followed by a blue coat.

8.7 All vapour barrier joints (longitudinal and circumferential) shall have a minimum overlap of 50 mm and shall be glued and taped.

8.8 Exposed vapour barrier shall be UV resistant.
9 APPLICATION

9.1 GENERAL

9.1.1 Where specified thickness of insulation exceeds commercially available sizes, insulation shall be applied in two or more layers, with all joints staggered and with overlaps of minimum 50mm. Insulation layers shall be strapped and glued into position.

9.1.2 Where cladding is required in terms of this specification, the standard for inland environments shall be "galvanised sheetmetal" and for marine environments, stainless steel or aluminium.

9.1.3 Cladding shall be strapped at 300mm intervals – no pop rivets or screws shall be used.

9.1.4 Installation material used on duct work, piping and plant operating at or below ambient dew point temperatures or installed in areas where the insulation can be soaked by (rain) water shall be of the closed cell type and shall be provided with a vapour seal (refer Clause 6). All joints on cladding shall be weather proof.

9.1.5 Equipment manufacturer’s nameplates shall not be covered by insulation.

9.1.6 Flanges, valves and strainers shall be insulated. Removable sections shall be insulated with synthetic rubber and taped.

9.1.7 Collars, bases and manholes of storage vessels shall be insulated. Manhole covers shall be semi removable. Storage vessel legs shall be insulated up to 50mm off the floor surface.

9.1.8 Heat exchangers shall be insulated.

9.1.9 Pumps and machinery shall not be insulated unless specifically indicated on the drawings.

9.1.10 All chilled water and refrigerant suction distribution systems shall be insulated and vapour sealed.

9.1.11 Cladding shall be compatible with the nature of material insulated and the vapour barrier. Where electrostatic build up or lightning strike is a possible given site conditions, cladding shall be earthed and bridged to ensure a continuous medium.

9.1.12 Cladding shall overlap a minimum of 30mm for <Ø150mm pipes and 50mm for ≥Ø150mm pipes.

9.1.13 To prevent thermal bridging at supports, insulation props of similar material, preformed to suit the pipe, sufficient density to support the pipe, fluid and coverings, and equal thickness to insulation shall be provided. Wooden blocks will not be accepted.

9.1.14 Material similar to Poly ISO Cyan Urate with a minimum density of 80kg/m³ and minimum length of 120mm can be used.

9.1.15 Minimum thickness specified in tables A – E, is based on thermal conductivity. The specialist insulation supplier should ensure that the correct thickness/density of material is used to prevent damage during construction and squashing at pipe supports.

9.1.16 Fixing of insulation shall allow for expansion of piping.

9.1.17 Condensate drain piping of equipment installed inside ceiling voids shall be insulated from the equipment to the drain point for a minimum distance of 2m or further if condensation is evident.
SUBJECT: INSULATION

PART C3.2: SECTION 04 PAGE 5 OF 11

9.1.18 Side stream filtration unit & piping and chilled water piping to and from dosing pod must be insulated.

9.1.19 External cladding and uninsulated sections of ducting that is exposed to rain shall be cross bend with the highest point in the centre of the ducting where installed horizontally to prevent standing water. No drilling of cladding on top of insulation is allowed.

9.1.20 External cladding seams of piping must be installed in a position that ensures there is no water ingress via the seam. The seam angle and overlap section must ensure efficient water run off and all joints must be water tight.

9.1.21 All insulated piping, including refrigerant piping shall be protected by a sheetmetal sleeve where it penetrates a structure and fire sealed if it is a fire wall.

9.1.22 When using preformed close cell foam insulation on piping a bonding medium similar to Bitumen must be used and applied over the protective coating that forms the basis of protection against corrosion.

9.1.23 The coverage of the Bitumen must be 100% of the insulated area.

9.1.24 All joints in insulation and termination against pipe supports must be glued.

9.1.25 Flexible connections shall not be insulated.

9.2 DUCTING

9.2.1 Refer to table D.

9.2.2 Duct insulation shall be fastened to ducting in accordance with the following table:

<table>
<thead>
<tr>
<th>DUCT SIZE</th>
<th>FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;300mm</td>
<td>Adhesive (100% coverage of area)</td>
</tr>
<tr>
<td>300mm ≤ duct &lt;600mm</td>
<td>Adhesive and straps at 300mm centres</td>
</tr>
<tr>
<td>≥ 600mm</td>
<td>Adhesive and pins at 300mm centres</td>
</tr>
</tbody>
</table>

9.2.3 If strapping is used in the installation, it shall be applied without damaging the insulation. Strapping shall be of the polypropylene type. Locking clips shall be plastic.

9.2.4 Pins shall be applied to sides and bottom. Mechanical pin washer shall not compress insulation more than 15%. Sharp edges of mechanical pin washers shall face away from the insulation to prevent damage to the vapour barrier.

9.2.5 No pins shall be used after HEPA filter but only straps.

9.2.6 The vapour barrier shall be re-instated after installation of pins.

9.2.7 Adhesive shall be applied to the bottom and sides of the duct to ensure bonding of the insulating material to the sheet metal.

9.2.8 The table below details the spacing of the mechanical fasteners for rigid internal and external insulating material.
9.2.9 Duct supports must not be against flanges/duct joints. Minimum distance from flanges/joints is 150mm.

9.2.10 At Coastal areas high density insulating material is required between the ducting and duct support bracket.

9.2.11 Ensure that the hangers and supports are large enough to allow the insulating material and the vapour barrier to be fitted between the duct and the hanger or support. Insert, between the duct and each hanger or support, a saddle of high density insulating material of acceptable quality, and of the same thickness as the insulating material with width at least equal to that of the carrying member (for example the angle). Ensure that the compressibility of the saddle material is such that, under working conditions, a saddle is not compressed to less than 85% of its original thickness. Bond the saddle onto the duct with 100% coverage of adhesive (refer to figure below for details). Fit saddles on all load-bearing surfaces of the external insulating material.
9.2.12 As an alternative to transverse joints specified in SANS 1238 the flanged joints such as MEZ-flanges will also be considered provided that these type of flanges meet the following specification.

<table>
<thead>
<tr>
<th>LONGEST SIDE OF DUCT (mm)</th>
<th>FLANGE HEIGHT (mm)</th>
<th>MATERIAL THICKNESS OF FLANGES</th>
<th>NO OF INTERMEDIATE CLAMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 300</td>
<td>20</td>
<td>1mm</td>
<td>Nil</td>
</tr>
<tr>
<td>300 – 600</td>
<td>20</td>
<td>1mm</td>
<td>1</td>
</tr>
<tr>
<td>601 – 1200</td>
<td>20</td>
<td>1mm</td>
<td>2</td>
</tr>
<tr>
<td>1201 – 1800</td>
<td>30</td>
<td>1.2mm</td>
<td>3</td>
</tr>
<tr>
<td>1801 – 2400</td>
<td>30</td>
<td>1.2mm</td>
<td>4</td>
</tr>
<tr>
<td>OVER 2400</td>
<td>TO SANS 1238</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9.2.13 MEZ-flanges or equivalent products shall be manufactured from cold rolled steel and hot-dip galvanised after manufacture. The sealant between mating flanges and between the flange and sheet-metal shall comply with SANS 1238.

9.2.14 Ductwork connected to equipment, such as cooling towers, evaporative condensers, plenum chambers etc. shall be provided with flanges for easy removal of the equipment.

9.2.15 “Where ducting passes through walls or partitions it shall have a suitable timber frame surrounding it. There shall be a 10mm clearance between all sides of the ducting and the timber frame.”

9.2.16 Strapping must not be used on bends and transformation sections. Mechanical pins must be used.

9.3 CHILLED WATER INSULATION

9.3.1 Refer to table A.

9.3.2 Flexible closed cell rubber insulation (Kaiflex) shall not be used on equipment exposed to Ambient conditions, lights, close to or near heat generated equipment.

9.3.3 Special Clauses for Coastal Application

The “Coastal Conditions” or “Coastal Application” shall be deemed to mean any installation within 35km of the ocean. For Coastal Conditions the following apply:

9.3.3.1 The vapour barrier must be sealed directly onto the chilled water pipe after the valve cluster of the cooling coil. This also applies where balancing valves or ball valves are used or flexible hose connections.
The insulation should overlap the vapour barrier. The vapour barrier must remain continuous on the outside of the pipe.

Where good thermal conducting vapour barrier such as aluminium foil is used, the foil should not come into contact with the pipe, but polyurethane foam or other closed cell insulation should rather be injected to seal the vapour barrier off, onto the pipe, after the valve cluster.

9.3.4 Refer to Section 09.02 for correct installation of balancing valve in pipe system.

The following vapour barrier materials are acceptable:

9.3.4.1 Mastic PK2415
9.3.4.2 SAFBOND cloth type
9.3.4.3 Foil to Mylar

The following type of vapour barrier are not acceptable:

9.3.4.4 Foilcraft

9.4 HOT WATER INSULATION

9.4.1 Refer to table B

9.4.2 Hot insulation shall provide adequate heat conservation and protection against burn injuries. Insulation surface temperature shall not exceed 50°C at an ambient of 30°C.
9.5 REFRIGERANT PIPING

9.5.1 Refer to table E.

9.6 STEAM

9.6.1 Refer to table C.

10 ACCEPTABLE CONTRACTORS

10.1 Insulation shall in all instances be applied by specialist “Insulation Contractors” and be of the highest standard. The Insulation contractor must be approved by Spoormaker & Partners

### TABLE A

**CHILLED WATER (INLAND CONDITIONS)**

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>Minimum R Value</th>
<th>Minimum Thickness/Thermal Conductivity</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m²K/W</td>
<td>0.038 – 0.05</td>
<td>0.034 – 0.038</td>
<td>0.022 – 0.024</td>
</tr>
<tr>
<td>15-50</td>
<td>0.5</td>
<td>25</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>65-80</td>
<td>0.66</td>
<td>40</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>100 - 300</td>
<td>0.79</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>&gt;=350 &quot;header&quot;</td>
<td>1.32</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>storage tanks</td>
<td>2.6</td>
<td>150</td>
<td>100</td>
<td>75</td>
</tr>
</tbody>
</table>

**CHILLED WATER (COASTAL CONDITIONS)**

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>Minimum R Value</th>
<th>Minimum Thickness/Thermal Conductivity</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m²K/W</td>
<td>0.038 – 0.05</td>
<td>0.034 – 0.038</td>
<td>0.022 – 0.024</td>
</tr>
<tr>
<td>15 - 22</td>
<td>0.66</td>
<td>40</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>25 - 40</td>
<td>0.79</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>50 - 100</td>
<td>1.0</td>
<td>50</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td>150 - 300</td>
<td>1.32</td>
<td>N/A</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>&gt;=350</td>
<td>2.0</td>
<td>N/A</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Storage tanks</td>
<td>2.6</td>
<td>n/a</td>
<td>100</td>
<td>75</td>
</tr>
</tbody>
</table>
### TABLE B

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>Minimum R Value</th>
<th>MINIMUM THICKNESS/ THERMAL CONDUCTIVITY</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>m²K/W</td>
<td>0.038 – 0.05</td>
<td>0.034 – 0.038</td>
<td>0.022 – 0.024</td>
</tr>
<tr>
<td>15 - 32</td>
<td>0.5</td>
<td>25</td>
<td>19</td>
<td>NA</td>
</tr>
<tr>
<td>40 - 100</td>
<td>0.5</td>
<td>25</td>
<td>19</td>
<td>NA</td>
</tr>
<tr>
<td>125 - 200</td>
<td>0.6</td>
<td>30</td>
<td>25</td>
<td>NA</td>
</tr>
<tr>
<td>&gt; 200</td>
<td>0.77</td>
<td>40</td>
<td>30</td>
<td>NA</td>
</tr>
</tbody>
</table>

### TABLE C

**C: STEAM AND CONDENSATE RETURNS**

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>Minimum R Value</th>
<th>MINIMUM THICKNESS/ THERMAL CONDUCTIVITY</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>m²K/W</td>
<td>0.038 – 0.05</td>
<td>0.034 – 0.038</td>
<td>0.022 – 0.024</td>
</tr>
<tr>
<td>15 - 32</td>
<td>0.66</td>
<td>25</td>
<td>25</td>
<td>NA</td>
</tr>
<tr>
<td>40 - 100</td>
<td>0.79</td>
<td>40</td>
<td>30</td>
<td>NA</td>
</tr>
<tr>
<td>125 - 200</td>
<td>1.0</td>
<td>50</td>
<td>40</td>
<td>NA</td>
</tr>
<tr>
<td>≥ 200</td>
<td>1.6</td>
<td>80</td>
<td>60</td>
<td>NA</td>
</tr>
</tbody>
</table>

### TABLE D

**EXTERNALLY INSULATED DUCTING**  
(No internally insulated ducting will be accepted unless specifically approved by the Engineer)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>Minimum R Value</th>
<th>MINIMUM THICKNESS/ THERMAL CONDUCTIVITY</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>m²K/W</td>
<td>0.038 – 0.05</td>
<td>0.034 – 0.038</td>
<td>0.022 – 0.024</td>
</tr>
<tr>
<td>All interior</td>
<td>0.5</td>
<td>25</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>All exterior</td>
<td>1.0</td>
<td>50</td>
<td>40</td>
<td>25</td>
</tr>
</tbody>
</table>

Exposed - 0.6mm galvanised sheet metal painted to an approved colour. External cladding arranged to shed water and all joints water tight, or double skin with vapour barrier.
## TABLE E

### REFRIGERANT PIPING

<table>
<thead>
<tr>
<th>SIZE</th>
<th>MINIMUM THICKNESS/ THERMAL CONDUCTIVITY</th>
<th>VAPOUR BARRIER</th>
<th>LOCATION/FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 100</td>
<td>0.038 – 0.05 0.034 – 0.038 0.022 – 0.024</td>
<td>NA 25 interior 15 interior</td>
<td>None for inside Refer to section 04 Clause 8 for outdoor installation</td>
</tr>
<tr>
<td>&gt;100</td>
<td>NA 40</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE F

#### EQUIPMENT SUBMISSION INFORMATION REQUIRED

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Minimum Requirement</th>
<th>Tendered</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Signed off specification</td>
<td>Included</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>The type of material/trademark of the material, volumetric mass in Kg/m³, operating range</td>
<td>Included</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>The coefficient of thermal conductivity in W/m°C (stabilized over time)</td>
<td>To suit material and thickness</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Confirmed thickness of insulation</td>
<td>To suit material and k-value</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Coefficient of thermal expansion in mm per °C</td>
<td>To suit installation method statement</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Water/moisture absorption properties</td>
<td>Absorb &lt;1% of weight in moisture</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Compressive strength</td>
<td>To suit material and thickness</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Confirm compliance with codes (section 2)</td>
<td>Complies fully</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Confirm compliance with fire specification (section 3)</td>
<td>Complies fully</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Confirm compliance with environmental specification (section 4)</td>
<td>Complies fully</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Minimum surface temperature in °C and confirmation that surface condensation will not occur.</td>
<td>To suit material and thickness</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Maximum surface temperature in °C</td>
<td>&lt; 50°C</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Expected heat gain/loss to end of typical pipe/duct run</td>
<td>&lt;2.5% of capacity for piping &lt;10% of capacity for ducting</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Detailed installation method statement</td>
<td>Included</td>
<td></td>
</tr>
</tbody>
</table>
SUBJECT: SOUND AND VIBRATION CONTROL

PART C3.2  SECTION 05  PAGE 1 OF 2

The Subcontractor shall be responsible for the rectification of any excessive noise and/or vibration caused by the operation of the air conditioning and ventilation system installed under this subcontract.

The Subcontractor shall be responsible for the detail design of concrete inertia blocks, if required or specified, but such blocks will be provided by others.

The Subcontractor shall be responsible for the detailed selection and design of bases and isolator in conformance with the requirements specified in latest ASHRAE – Handbook-HVAC Applications – Section 48 - Noise and Vibration Control - Guide for Selection of Vibration Isolators.

1 ISOLATION OF MECHANICAL EQUIPMENT

1.1 All equipment shall be orientated or screened in such a way that maximum sound radiation patterns are directed so as to cause least disturbance.

1.2 All rotating machinery shall be balanced. The critical speed shall be at least 20% above the operating speed.

1.3 Vibration isolation mountings shall be provided for all vibration inducing equipment and associated pipe work and ducting. Mountings shall be installed in accordance with the manufacturer's instructions. However, the Subcontractor shall be responsible to ensure that amplitude of motion and vibration transmission will not exceed the specified limits.

1.4 Floor mounted equipment shall be erected on a concrete plinth, which shall protrude at least 25 mm above finished screeded floor level.

1.5 Isolators shall be selected to give both horizontal and vertical flexibility (compression and shear). The amplitude of motion due to operation of the supported equipment shall not exceed 3 mm.

1.6 Spring isolators shall be designed and installed in such a way that the ends of the springs are constricted to remain parallel during deflection. For stability, the outside diameter of springs shall be at least equal to their compressed height at rated load. Springs shall have a minimum additional travel to solid, equal to 20% of the rated deflection. Each spring mounting shall be set on 7 mm thick neoprene acoustical pads.

1.7 Ceiling mounted equipment must be provided with AV mountings as per suppliers instructions.

1.8 Vibration isolation mounts for axial fans are to be secured by bolting it into position i.e. to a fixed steel/concrete structure. Care is to be taken not to drill through water proofing.

2 ISOLATION OF PIPING AND DUCTS

2.1 All connections to equipment shall be sufficiently flexible to prevent excessive strain to allow the equipment freedom to move and to prevent plant vibration being conducted. Initially, special flexible connection may be omitted in a piping system and use shall be made of natural flexibility of resilient hangers or mountings for vibration isolation. However, flexible connections shall be inserted and other necessary adjustments be made, at the Subcontractor's expense, should the need arise.

2.2 All ductwork and piping within 15 m from connected vibration-inducing equipment shall be hung on resilient hangers. The first four hanger supports shall be capable of supporting piping at a fixed elevation during installation and, in addition, shall have a secondary adjustment to transfer the load to the spring element within the mounting, after the system has been filled with water.

2.3 The Subcontractor may be required to disconnect the piping after the installation is completed to demonstrate that no strain is exerted at the connections to the equipment.
2.4 Noise suppressors shall be installed downstream of all steam pressure reducing valves.

2.5 Where piping and ductwork passes through walls, floors or ceilings or plantrooms, acoustical seals shall be employed to confine airborne noises to the inside of such rooms.

3 SOUND ATTENUATION

3.1 Sound attenuating units or treatment shall be provided as indicated and/or required to control the noise from air conditioning and ventilation systems to within the limits specified.

3.2 It should be noted that the provisions for sound attenuation shown on the Engineer’s drawings (or the absence of same) are based on average published data for equipment noise and inherent attenuation. The Subcontractor shall, nevertheless produce his own calculations, and select isolators/isolating methods following a recognised certified method and Guidelines - ASHRAE Systems Volume Chapter 32 for noise levels in the areas specified for the sound power of the actual selected equipment, and provide additional silencing equipment and/or treatment if necessary.

3.3 To minimise the need for sound attenuation, fans shall be selected to operate near their maximum efficiency point when producing the required air quantity and static pressure.

3.4 Sound attenuators and acoustic treatment in ducts shall be fire, fungus and erosion proof.

3.5 "Package" attenuators shall normally be flanged for bolted connections, and flexible duct connectors shall be used as shown or required.

3.6 Attenuators shall have an air resistance not exceeding 75 Pa measured at sea level at maximum air quantity.

3.7 Attenuating material must be fixed, glued and covered to supplier’s specification to prevent decay of material in air stream.

3.8 The attenuator entering face profile must be curved in order to reduce possibility of air noise and reduce pressure drop across attenuator.

4 NOISE MEASUREMENT

4.1 The Subcontractor shall submit sound pressure levels measured on the completion of the installation, detailing the sound pressure levels in dB (re: 2 x 10^-5N/m²), for the seven International Standard Octave Bands measured by means of a sound meter in at least six (6) areas within the building, as selected by the Architect.

4.2 Measurements for sound pressure level data shall be taken by the Subcontractor, or at his expense by an approved organisation, under full or nearly full cooling and air flow conditions.
1 ENERGY CONSUMPTION AND MAINTENANCE COSTS

1.1 The annual cost of energy consumed and total annual maintenance and service costs are an essential input in the adjudication process to select the appropriate equipment/tender. The selection will be based on the lowest total life cycle cost for a 15 year period. The present day tender price which might be used in comparing the various tenders is based on the application of a present day cost formula which allocates the appropriate influence to:

1.1.1 Initial Capital Cost.

1.1.2 Estimated Annual Electricity Costs.

1.1.3 The Annual Maintenance Costs.

1.1.4 The Average Interest Rate.

1.1.5 The Estimated Energy Costs Escalation Rate.

1.1.6 The Estimated Labour and Material Escalation Rate (Consumers Index).

1.2 Because initial cost is not the only determining factor, tenderers are advised to carefully consider energy efficiency and quality of equipment offered, if requested in the Schedules of Components and Equipment.
1. **FUNCTIONAL PERFORMANCE**

1.1 This specification to be read in conjunction with the relevant drawing(s).

1.2 **OPERATING RANGE**

   Fan delivery shall not decrease more than 10% when filters are dirty. The operation point shall be on a stable part of the fan curve.

1.3 **SAFETY**

1.3.1 Fan motor shall be non-overloading at any operating point of its performance curve.

1.3.2 Safety protection shall be provided for the motors as follows, unless otherwise specified:

   1.3.2.1 Single phase motors - Thermal overload protection
   1.3.2.2 Three phase motors - Thermal overload and phase failure protection.

1.4 **EQUIPMENT SYSTEM OPERATION**

1.4.1 Units shall be provided with a minimum of the following for manual operation:

   1.4.1.1 On/Off facility
   1.4.1.2 Fan operation only
   1.4.1.3 Cooling operation (fan and pump)

   The controls shall be clearly marked and easy to operate.

1.4.2 It shall be possible to slave up to ten units on one controller. Controllers shall be housed in the electrical board where space shall be provided.

1.5 **SELECTION**

Evaporative cooling units shall be Biocool or equal approved suitable for mounting on the roof.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWNTIME**

2.1.1 The replacement of the fan shall not exceed 2 days.

2.1.2 The replacement of the spray pump shall not take longer than one day, while the cleaning of nozzles shall not take longer than 2 hours.

2.2 **MEAN TIME BETWEEN FAILURES**

The minimum allowable mean time between failures of any of the units' sub-components and based on the acceptance of a Comprehensive Maintenance Contract is 10 years.
2.3 COMPREHENSIVE MAINTENANCE CONTRACT

Only suppliers/manufacturers that offer, and submit proof that they can honour a 5 year Comprehensive Maintenance Contract (renewable for another 5 years at the option of the Building Owner) will be considered as acceptable suppliers.

2.4 DOCUMENTATION

Subcontractor shall submit, service, maintenance, trouble shooting, testing, installation and start-up instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the Equipment Part of the O & M Manual Part C1.5 Section 18.

3. TECHNICAL RESTRAINTS

3.1 Maximum unit dimensions and component arrangement shall comply with general arrangement drawing.

3.2 UNIT CASING

3.2.1 Casing shall be constructed of UV resistant polymer plastic or equal, which has a service life of at least 10 years without fading, deteriorating or leaking air and water.

3.2.2 Access panel/doors shall be installed in the casing where required for inspection, maintenance and replacement of equipment, instruments and controls.

3.2.3 The casing shall be suitably reinforced to carry the panel’s own weight, water sump and the air pressure differential.

3.2.4 Unit casing shall be weatherproof and corrosion free for at least 15 years.

3.3 EVAPORATIVE PADS

3.3.1 Evaporative pads shall be minimum 90mm thick. The design of the pad shall ensure that water is evenly distributed over the face area of the pad and over its thickness to ensure saturation of the air as it passes through the pad.

3.3.2 Water shall be automatically drained from the sump, three hours after the unit has been switched off to ensure total dissolved solids in water is kept in control.

3.4 SUPPLY FAN

3.4.1 The supply fan shall be either of the axial type with inlet cone or of the double inlet centrifugal type with backward curved impeller.

3.4.2 The fan motor shall be suitable for minimum three speed control – low, medium and high.

3.4.3 Fan and motor assembly shall be installed on a galvanised steel channel base and isolated from the supporting structure by spring vibration isolators and neoprene pads.

3.4.4 Bearings shall be self-aligning, pillow block re-greaseable type, selected for an average life of 30 000 hours at design operating conditions.

3.4.5 Fan wheels shall be keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor load. Fans and shafts shall be selected to operate at least 25% below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. After final assembly, the entire unit shall be given a final vibration test.
3.4.6 Fan shall be direct or belt driven and shall have readily adjustable provision to provide variation in centre distance.

3.4.7 Belts shall be of the oil resistant type and shall be selected for 30,000 operating hours at a minimum of 1.2 times the motor rating, and one slip free start per day.

3.4.8 The motor shall be of the totally enclosed fan cooled type. The motor starter, motor and drive shall be selected to ensure slip free starting without unacceptable voltage drop.

3.4.9 The fan shall be selected assuming a pressure drop across the pad equal to the average pressure drop caused by the pad in its clean and dirty states.

4. BUILDING RESTRAINTS

4.1 The operating mass of the unit shall not exceed 120kg

5. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

5.1 Subcontractor shall supply the necessary field testing instruments (thermometers and flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ±5% for Unit performance acceptance testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/tables to confirm that claimed performance is achieved.

5.3 Evidence of "Inspection Passed" in accordance with the specified Quality Management System shall be submitted, together with the relevant component serial numbers.
6. SCHEDULE - SINGLE STAGE EVAPORATIVE COOLING UNIT

**THIS IS EXISTING EQUIPMENT IGNORE THE TABLE BELOW**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Refer Note</th>
<th>Units</th>
<th>Tender</th>
<th>Offered</th>
<th>Tender</th>
<th>Offered</th>
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<tbody>
<tr>
<td>- Identification No/Service</td>
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<tr>
<td><strong>Supply Fan</strong></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- Flow rate - maximum</td>
<td></td>
<td>(m³/s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>- Flow rate - minimum</td>
<td></td>
<td>(m³/s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fan external static press.</td>
<td>2</td>
<td>(Pa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Variable speed motor</td>
<td></td>
<td>(YES/NO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Humidifier</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Entering air condition</td>
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<td>(^°CdB/°CwB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Leaving air conditioning</td>
<td></td>
<td>(^°CdB/°CwB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>- Degree of humidification</td>
<td></td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Air flow rate - maximum</td>
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<td>(m³/s)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>- Water flow rate</td>
<td>2</td>
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<td></td>
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<td>- Water supply pressure</td>
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<td>(kPa)</td>
<td></td>
<td></td>
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<td><strong>Power Supply</strong></td>
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<tr>
<td>- Volt/phase/frequency</td>
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<td>(V/ Hz)</td>
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<td></td>
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<tr>
<td><strong>Equipment absorbed power at design conditions</strong></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>- Supply air fan motor</td>
<td></td>
<td>(kW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Humidifier pump motor</td>
<td></td>
<td>(kW)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**NOTES**

1. All figures given are for 1 600m above sea level
2. Estimated for tendering purposes only. To be confirmed at time of equipment submission.
1. **FUNCTIONAL PERFORMANCE**

1.1 This specification to be read in conjunction with the relevant SICO drawing(s).

1.2 **OPERATING RANGE**

Fan delivery shall not decrease more than 10% when filters are dirty. The operation point shall be on a stable part of the fan curve.

1.3 **SAFETY**

1.3.1 Fan motor shall be non-overloading at any operating point of its performance curve.

1.3.2 Safety protection shall be provided for the motors as follows, unless otherwise specified:

1.3.2.1 Single phase motors - Thermal overload protection
1.3.2.2 Three phase motors - Combined thermal overload and phase failure protection.

1.4 **EQUIPMENT SYSTEM OPERATION**

1.4.1 Refer SICO

1.4.2 All necessary instrumentation, including bulkhead plenum lights, inspection and testing provisions to enable the Operator to log performance and identify malfunctioning of equipment, in accordance with trouble shooting instructions, shall be installed and grouped together in such a way as to facilitate logging with maximum accuracy and reduce Operator's time to a minimum.

1.4.3 The physical location of all specified or implied instrumentation shall be indicated on the shop drawings and or installation drawings.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWNTIME**

2.1.1 The construction and assembly details of the factory assembled Unit shall allow the water cooling coil to be removed while supply fan remains running without disturbing the fan.

2.1.2 Downtime of unit for the following repairs shall not exceed 2 days:

2.1.2.1 Replacement of cooling coil.
2.1.2.2 Replacement of fan.

2.1.3 The replacement of the spray pump shall not take longer than one day, while the cleaning of nozzles shall not take longer than 2 hours.

2.2 **MEAN TIME BETWEEN FAILURES**

The minimum allowable mean time between failures of any of the units' sub-components and based on the acceptance of the specified Comprehensive Maintenance Contract is 10 years.
(Refer PART C4.7)
2.3 COMPREHENSIVE MAINTENANCE CONTRACT

Only suppliers/manufacturers who offer, and submit proof that they can honour a 5 year Comprehensive Maintenance Contract (renewable for another 5 years at the option of the Building Owner) will be considered as acceptable suppliers. (Refer PART C4.7)

2.4 DOCUMENTATION

Supplier of Unit shall submit, service, maintenance, trouble shooting, testing, installation and start-up instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the Equipment Part of the O & M Manual. (Part C1.5 Section 18).

3. TECHNICAL RESTRAINTS

3.1 Maximum unit dimensions and component arrangement shall comply with general arrangement drawing. 

3.2 UNIT CASING

3.2.1 The factory assembled, sectionalised double wall insulated casing must provide repair and/or removal access through easily removable panels to the various unit parts such as fan, coil, sprays etc.

3.2.2 Sealed type bulkhead plenum lights shall be provided in each separate compartment.

3.2.3 A light switch with pilot light shall be provided next to the access door leading into the compartment.

3.2.4 The light fittings and wiring shall be suitably moisture proofed.

3.2.5 Insulation shall be in accordance with Part C3.2, Clause 4.

3.2.6 Casing construction shall be in accordance with SMACNA Standards or approved similar and/or equal.

3.2.7 Access doors shall be installed in the casing where shown, and where required for inspection, maintenance and replacement of equipment, instruments and controls.

3.2.8 Access doors shall be of the walk-in type, minimum 600 mm wide and 1200 mm high, consisting of a double skin insulated door, panel and frame. The frame shall have a profiled rubber seal.

3.2.9 Access doors shall be of the hinged type and shall open against the air pressure. The two (minimum) door handles shall be of robust construction. A lock shall be provided. The doors shall be openable from either side.

3.2.10 Access doors to the spray plenum shall incorporate a double glazed view window.

3.2.11 The roof and sides shall be suitably reinforced to carry the panel's own weight, people traffic and the air pressure differential.

3.2.12 Unit shall be weatherproof.

3.3 PRE-FILTER AND MAIN FILTER BANK

3.3.1 Filter frame shall be suitable for standard commercial range of filter elements and filter media available.

3.3.2 Air filter gauge - type Magnahelic or equal approved - shall be provided for each filter bank.

3.3.3 Adequate personnel access shall be provided in front of filter bank if filter elements are removed from front.

3.3.4 The filter elements and filter frame shall be fully corrosion protected. Construction of filter frame, and method of holding
3.4 COOLING COIL SECTION

3.4.1 Coil sections shall have heavy duty coil tracks extending the full width of the unit to provide easy slip-in, slip-out coils for ease of service and maintenance.

3.4.2 Piping connections to coils shall be flanged and so arranged that independent coil replacement is possible.

3.4.3 Cooling coil, connections and return bends shall be tested to 2000 kPa and rated for operation at 1700 kPa.

3.4.4 The coil section shall have a stainless steel frame.

3.5 SPRAY SECTION

3.5.1 The complete spray section and its components shall be made from non-corrosive material (stainless steel, glass fibre, PVC etc.)

3.5.2 The spray section shall have an upstream device (straighteners or the like) to affect the air flow in such a manner as to achieve a minimum degree of humidification at the end of the spray section as specified on page 6 of Part C3.3 Section 02.02.

3.5.3 The spray section shall have a downstream eliminator to prevent any carry-over of water droplets into the fan section. Eliminator sections shall slide in tracks for easy removal and cleaning through removable side panels.

3.5.4 A sump shall be provided under the cooling coil, spray section and eliminator. The sump shall slope from all sides to one or more trapped drain connections.

3.5.5 The spray nozzles shall be of the self-cleaning, non-clogging type and easily removable for maintenance.

3.5.6 The spray water reticulation system shall be provided with a primary and secondary fine filter suitable for spray nozzles selected. Both filters to be easily cleanable during normal daily maintenance.

3.5.7 A walkway shall be provided inside the spray section for access to nozzles and for cleaning purposes.

3.6 SUPPLY FAN

3.6.1 The supply fan shall be of the double inlet type with backward curved impeller.

3.6.2 The fan motor shall be suitable for speed control if specified as such in the schedule.

3.6.3 Fan and motor assembly shall be installed on a steel channel base and isolated from the supporting structure by spring vibration isolators and neoprene pads.

3.6.4 Bearings shall be self-aligning, pillow block re-greaseable, selected for an average life of 200,000 hours at design operating conditions.

3.6.5 Fan wheels shall be keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor load. Fans and shafts shall be selected to operate at least 25% below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. After final assembly, the entire unit shall be given a final vibration test.

3.6.6 Fan shall be belt driven and shall have readily adjustable provision to provide variation in centre distance.

3.6.7 Belts shall be of the oil resistant type and shall be selected for 100,000 operating hours at a minimum of 1.2 times the motor rating, and one slip free start per day.
3.6.8 The motor shall be of the totally enclosed fan cooled type. The motor starter, motor and drive shall be selected to ensure slip free starting without unacceptable voltage drop.

3.6.9 The fan shall be selected assuming a pressure drop across the filter equal to the average pressure drop caused by the filter in its clean and dirty states.

3.7 ELECTRIC HEATER SECTION

3.7.1 The electric heater shall be complete with:

3.7.1.1 Auto reset thermal cut-out device set at 65°C

3.7.1.2 Manual re-set thermal cut-out device set between 80-100°C with re-set button, labelled and operable without removing any terminal box cover.

3.7.1.3 Air flow interlock by means of either supply air pressure switch, or air flow switch.

3.7.2 Elements shall have an adequate resistance to earth.

3.8 AUTOMATIC DAMPERS

3.8.1 The dampers shall be of the opposed blade type and shall be interlinked with a robust geared mechanism.

3.8.2 The blades shall be of aerofoil section with neoprene blade seal at one edge; they shall not be wider than 165 mm and supported at intervals of not more than 800 mm by maintenance-free non-lubrication type bearings.

3.8.3 The operating mechanism shall be within the overall size of the damper frame, except for the drive arm and the motor platform.

The arm shall be clearly visible and marked “open-closed”.

3.8.4 The leakage rate, with the damper in a fully closed position shall not be more than 150 l/s per m² at a pressure differential of 100 Pa.

4. BUILDING RESTRAINTS

The piping system shall be adequately supported so that no strain is imposed on the coil connections.

5. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

5.1 Subcontractor shall supply the necessary field testing instruments (thermometers and flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 5% for Unit performance acceptance testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/tables to confirm that claimed performance is achieved.

5.3 Evidence of "Inspection Passed" in accordance with the specified Quality Management System shall be submitted, together with the relevant component serial numbers.
### 6. SCHEDULE - TWO STAGE EVAPORATIVE COOLING UNIT

**THIS IS EXISTING UNITS, IGNORE THE TABLE BELOW**

<table>
<thead>
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<th>Identification</th>
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<th>Units</th>
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<tr>
<td>- Drawing No. Reference</td>
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<tr>
<td>- No. off</td>
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</tbody>
</table>

**Supply Fan**
- Flow rate - maximum (m³/s)
- Flow rate - minimum (m³/s)
- Fan total static pressure (Pa)
- Variable speed motor (YES/NO)

**Cooling Coil**
- Entering air condition (°C db/°C wb)
- Leaving air condition (°C db/°C wb)
- Entering water temperature (°C)
- Leaving water temperature (°C)
- Air flow rate (m³/s)
- Water flow rate (l/s)
- Capacity - total (kW)
- Capacity - sensible (kW)
- Minimum number of rows | | |
- Max. no. of fins per 25 mm (f.p.i.) |
- Material of tubes | |
- Material of fins | |

**Humidifier**
- Entering air condition (°CdB/°CwB)
- Leaving air condition (°CdB/°CwB)
- Degree of humidification (%) | |
- Air flow rate - maximum (m³/s) |
- Water flow rate 2 (l/min) |
- Water supply pressure (kPa) |

**Heater (Electric)**
- Air flow rate (m³/s) |
- Capacity (kW) |
- No. off control steps | |
### Pre-Filter

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<th>Reference</th>
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<tr>
<td>- Maximum velocity</td>
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<td>(%)</td>
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<td>- Final resistance</td>
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### Main Filter

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### Return Air Dampers

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<tr>
<td>- Flow rate - minimum</td>
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<td>(m(^3)/s)</td>
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<td>- Max. face velocity</td>
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### Outside Air Dampers

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<td>- Flow rate - maximum</td>
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<td>(m(^3)/s)</td>
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<td>- Flow rate - minimum</td>
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<tr>
<td>- Max. face velocity</td>
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### Power Supply

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### Equipment absorbed power at design conditions

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<tbody>
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<td>(kW)</td>
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<td>- Humidifier pump motor</td>
<td></td>
<td>(kW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Heater (Electric)</td>
<td></td>
<td>(kW)</td>
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### NOTES

1. All figures given are for an altitude as specified in Part C3.1
2. Estimated for tendering purposes only. To be confirmed at time of equipment submission.
3. As per ASHRAE 52-76.
1. **FUNCTIONAL PERFORMANCE**

1.1 This specification to be read in conjunction with the relevant SICO drawing(s).

1.2 **OPERATING RANGE**

Fan delivery shall not decrease more than 10% when filters are dirty. The operation point shall be on a stable part of the fan curve.

1.3 **SAFETY**

1.3.1 Fan motor shall be non-overloading at any operating point of its performance curve.

1.3.2 Safety protection shall be provided for the motors as follows, unless otherwise specified:

- 1.3.2.1 Single phase motors - Thermal overload protection
- 1.3.2.2 Three phase motors - Combined thermal overload and phase failure protection.

1.4 **EQUIPMENT SYSTEM OPERATION**

1.4.1 Refer SICO

1.4.2 All necessary instrumentation, inspection and testing provisions to enable the Operator to log performance and identify malfunctioning of equipment, in accordance with trouble shooting instructions, shall be installed and grouped together in such a way as to facilitate logging with maximum accuracy and reduce Operator's time to a minimum.

The physical location of all specified or implied instrumentation shall be indicated on the shop drawings and or installation drawings.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWNTIME**

2.1.1 The construction and assembly details of the factory assembled unit shall allow the supply fan to be running without the evaporative media and cooling coil in position. The air must be filtered as such.

2.1.2 Downtime of unit for the following repairs shall not exceed 2 days:

- 2.1.2.1 Replacement of cooling coil.
- 2.1.2.2 Replacement of fan.

2.1.3 The replacement of the pump shall not take longer than one day.

2.2 **MEAN TIME BETWEEN FAILURES**

The minimum allowable mean time between failures of any of the units' sub-components and based on the acceptance of the specified Comprehensive Maintenance Contract is 10 years. [Refer PART C4.7].

2.3 **COMPREHENSIVE MAINTENANCE CONTRACT**

Only suppliers/manufacturers who offer, and submit proof that they can honour a 5 year Comprehensive Maintenance Contract (renewable for another 5 years at the option of the Building Owner) will be considered as acceptable suppliers. [Refer PART C4.7]

2.4 **DOCUMENTATION**

Supplier of Unit shall submit, service, maintenance, trouble shooting, testing, installation and start-up instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the Equipment Part of the 0 & M Manual. [Part C1.5 Section 18]
3. TECHNICAL RESTRAINTS

3.1 Maximum unit dimensions and component arrangement shall comply with general arrangement drawing and relevant SICO drawings.

3.2 UNIT CASING

3.2.1 Unit casing shall be manufactured from 3CR12 stainless steel panels.

3.2.2 Unit casing shall be self-supporting.

3.2.3 Access doors shall be installed and shall form a tight seal with the unit casing.

3.2.4 Access doors shall provide necessary access to all equipment installed in unit for inspection, maintenance and replacement of equipment, instruments and controls.

3.2.5 Access doors shall be of the hinged type and shall open against the air pressure. The two (minimum) door handles shall be of robust construction. A lock shall be provided. The doors shall be openable from either side.

3.2.6 All exterior surfaces shall be 3CR12.

3.2.7 Unit shall be weatherproof.

3.3 PRE-FILTER AND MAIN FILTER BANK

3.3.1 Filter frame shall be suitable for standard commercial range of filter elements and filter media available.

3.3.2 Air filter gauge - type Magnahelic or equal approved - shall be provided for each filter bank.

3.3.3 Adequate personnel access shall be provided in front of filter bank for removal of filter for cleaning or replacing purposes.

3.3.4 The filter elements and filter frame shall be fully corrosion protected. Construction of filter frame, and method of holding down filter elements shall ensure no passage of unfiltered air through filter bank.

3.4 COOLING COIL AND PIPING SECTION

3.4.1 Coil sections shall have heavy duty coil tracks extending the full width of the unit to provide easy slip-in, slip-out coils for ease of service and maintenance.

3.4.2 Pipe connections to coils shall be as such that replacement of coil is possible.

3.4.3 Cooling coil, connections and return bends shall be tested to 2000 kPa and rated for operation at 1700 kPa.

3.4.4 The coil section shall have a stainless steel frame.

3.4.5 Water distribution to the coils shall be a minimum of Class 4 PVC piping.

3.4.6 Water make-up connection shall be 20mm copper and the ball valve and copper float shall control water level in sump.

3.4.7 Bleed off control valve shall be provided that will drain directly into the overflow upon pump start-up.

3.5 EVAPORATIVE MEDIA

3.5.1 Media shall be manufactured from special cellulose paper, impregnated with insoluble anti-rot salts and rigidifying saturates.
3.5.2 Media shall be a minimum of 300mm deep.

3.5.3 Saturation efficiency shall be a minimum of 90% at 3m/s face velocity.

3.5.4 No moisture will be carried over up to 4m/s.

3.5.5 Media shall be a cross-fluted self-cleaning design.

3.5.6 Distribution headers shall be provided above the evaporative media packs to ensure equal water distribution over the media pack length.

3.5.7 Sump of sufficient capacity shall be provided under the evaporative media.

3.5.8 Sump shall be manufactured from 2mm CR12 and shall extend sufficiently towards the face and leaving ends of the evaporative media to prevent any loose droplets from splashing on the unit casing floor.

3.5.9 There shall be no by-pass of air under, above or at the sides of the evaporative media pack.

3.6 SUPPLY FAN - PRIMARY

3.6.1 The supply fan shall be of the double inlet type with backward curved impeller.

3.6.2 The fan motor shall be suitable for speed control if specified as such in the schedule.

3.6.3 Fan and motor assembly shall be installed on a steel channel base and shall be vibration isolated from the supporting structure.

3.6.4 Bearings shall be self-aligning, pillow block re-greaseable, selected for an average life of 200 000 hours at design operating conditions.

3.6.5 Fan wheels shall be keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor load. Fans and shafts shall be selected to operate at least 25% below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. After final assembly, the entire unit shall be given a final vibration test.

3.6.6 Fan shall be belt driven and shall have readily adjustable provision to provide variation in centre distance. Fan belt shall be equipped with a belt guard.

3.6.7 Belts shall be of the oil resistant type and shall be selected for 100,000 operating hours at a minimum of 1.2 times the motor rating, and one slip free start per day.

3.6.8 The motor shall be of the totally enclosed fan cooled type. The motor starter, motor and drive shall be selected to ensure slip free starting without unacceptable voltage drop.

3.6.9 The fan shall be selected assuming a pressure drop across the filters equal to the average pressure drop caused by the filter in its clean and dirty states.

3.7 COOLING TOWER FANS - SECONDARY

3.7.1 Fans shall be fitted with aerodynamically shaped blades balanced for quiet operation.

3.7.2 Fan motor shall be of the totally enclosed fan cooled type with pre-lubricated sealed ball bearings.

3.7.3 The inlet to the fan shall be a smooth bell mouth shape.

3.7.4 Fan outlets shall be fitted with vermin screens if no ducting is attached to the discharge side of the fan.
3.8 ELECTRIC HEATER SECTION

3.8.1 The electric heater shall be complete with:
  3.8.1.1 Auto reset thermal cut-out device set at 65°C
  3.8.1.2 Manual re-set thermal cut-out device set between 80-100°C with re-set button, labelled and operable without removing any terminal box cover.
  3.8.1.3 Air flow interlock by means of either supply air pressure switch, or air flow switch.

3.8.2 Elements shall have an adequate resistance to earth.

3.9 AUTOMATIC DAMPERS

3.9.1 The dampers shall be of the opposed blade type and shall be interlinked with a robust geared mechanism.

3.9.2 The blades shall be of aerofoil section with neoprene blade seal at one edge; they shall not be wider than 165 mm and supported at intervals of not more than 800 mm by maintenance-free non-lubrication type bearings.

3.9.3 The operating mechanism shall be within the overall size of the damper frame, except for the drive arm and the motor platform.

The arm shall be clearly visible and marked "open-closed".

3.9.4 The leakage rate, with the damper in a fully closed position shall not be more than 150 l/s per m² at a pressure differential of 100 Pa.

3.10 PUMP

3.10.1 Unit shall be fitted with a single pump per module.

3.10.2 Pump shall be of centrifugal type placed inside the unit casing.

4. BUILDING RESTRAINTS

The piping system shall be adequately supported so that no strain is imposed on the coil connections.

5. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

5.1 Subcontractor shall supply the necessary field testing instruments (thermometers and flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 5% for Unit performance acceptance testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/tables to confirm that claimed performance is achieved.

5.3 Evidence of "Inspection Passed" in accordance with the specified Quality Management System shall be submitted, together with the relevant component serial numbers.
6. SCHEDULE - TWO STAGE EVAPORATIVE COOLING UNIT

**THIS IS EXISTING UNITS, IGNORE THE TABLE BELOW**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Refer Note</th>
<th>Units</th>
<th>Tender</th>
<th>Offered</th>
<th>Tender</th>
<th>Offered</th>
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<td></td>
<td></td>
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<td>No. off</td>
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<td>Maximum velocity</td>
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<td></td>
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<tr>
<td>-</td>
<td></td>
<td>Efficiency</td>
<td>3 (%)</td>
<td></td>
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<tr>
<td>-</td>
<td></td>
<td>Arrestance</td>
<td>3 (%)</td>
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<td></td>
<td></td>
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<tr>
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<td>Initial resistance</td>
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### Main Filter

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<td>Efficiency</td>
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<td>Arrestance</td>
<td>3 (%)</td>
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<td>Final resistance</td>
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### Return Air Dampers

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<th>Tender</th>
<th>Offered</th>
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<tr>
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<td></td>
</tr>
<tr>
<td>Flow rate - minimum</td>
<td>(m³/s)</td>
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</tr>
<tr>
<td>Max. face velocity</td>
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### Outside Air Dampers

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<th>Tender</th>
<th>Offered</th>
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</thead>
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<tr>
<td>Flow rate - maximum</td>
<td>(m³/s)</td>
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<td></td>
</tr>
<tr>
<td>Flow rate - minimum</td>
<td>(m³/s)</td>
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<td></td>
</tr>
<tr>
<td>Max. face velocity</td>
<td>(m/s)</td>
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### Power Supply

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<th>Tender</th>
<th>Offered</th>
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</thead>
<tbody>
<tr>
<td>Volt/phase/frequency</td>
<td>(V/pa/Hz)</td>
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### Equipment absorbed power at design conditions

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<thead>
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<th>Units</th>
<th>Tender</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply air fan motor - primary</td>
<td>(kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling tower fan motor - secondary</td>
<td>(kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidifier pump motor</td>
<td>(kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heater (Electric)</td>
<td>(kW)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NOTES

1. All figures given are for an altitude as specified in Part C3.1.
2. Estimated for tendering purposes only. To be confirmed at time of equipment submission.
3. As per ASHRAE 52-76.
4. Based on a minimum efficiency of 80%.
5. Equal to 1st stage entering condition.
6. Based on fan motor to deliver total static pressure.
FUNCTIONAL PERFORMANCE

1.1 CAPACITY CONTROL

1.1.1 The vane pitch shall be manually adjustable.

1.2 OPERATING RANGE

1.2.1 The operation point shall be in the stable part of the curve.

1.3 SAFETY

1.3.1 Fan motor shall be non-overloading at any operating point.

1.3.2 Safety protection shall be provided for the motors as follows, unless otherwise specified:

- 1.3.2.1 Single phase motors - Thermal overload protection.
- 1.3.2.2 Three phase motors - Combined thermal overload and phase failure protection.

RELIABILITY AND AVAILABILITY

2.1 DOWN TIME

2.1.1 Fans shall be so constructed and installed that any sub-component replacement shall not take longer than 1 day when executed by qualified building maintenance staff [Refer PART C4.7].

2.2 DOCUMENTATION

2.2.1 The Subcontractor shall submit service, maintenance, trouble shooting, testing, installation and start-up instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the equipment part of the O & M Manual. [Refer Part C1.5 Section 18].

TECHNICAL RESTRAINTS

3.1 Fan assembly shall be statically and dynamically balanced at the manufacturer's works within the design operating speed range.

3.2 Rotation arrow shall be installed.

3.3 Motor shall be of the totally enclosed, squirrel cage induction, constant speed, continuous duty, variable torque type.

3.4 Fan shall be direct connected with motor inside the fan casing.

3.5 Fan assembly shall be suitable for vertical or horizontal mounting

3.6 Motor conduit box shall be mounted on exterior of fan casing. Lead wires from motor to conduit box shall be protected from the air stream.

3.7 Motor rating shall not be less than the maximum power required by the fan at any operating point between zero and break-off capacity for the fan wheel furnished.

3.8 The fan motor shall be of the variable speed type, if specified as such in the schedule.
**BUILDING RESTRAINTS**

4.1 Fan assembly shall be installed in accordance with manufacturer's recommendations.

4.2 Fan assembly shall be isolated from duct and structure by flexible connection and vibration isolation mountings in accordance with Part C3.2 Clause 5. Vibration isolation mounts for axial fans are to be secured by bolting it into position i.e. to a fixed steel/concrete structure. Care is to be taken not to drill through waterproofing.

4.3 Fan shall not be operated until connected ducts have been cleaned and specified filters have been put into regular operating condition.

4.4 Fan casing shall not drum, distort or leak at any operating point and shall, if necessary, be externally sound insulated to maintain specified noise levels.

4.5 Anchors that were not installed to the suppliers recommended procedures will not be accepted.

4.6 Washes shall be fitted to each nut and bolt.

**"MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION**

5.1 Subcontractor shall supply the necessary field testing instruments and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 5% for the Fan Acceptance Testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/table to confirm that claimed performance is achieved.

5.3 The various tests as required by the Quality Management System, shall be demonstrated and accessible to the Engineer at all times for monitoring.

**SCHEDULE**

6.1 Refer layout drawings for schedules.

6.2 All figures given are for an altitude as specified in Part C3.1.

6.3 Pressure and absorbed power figures are for tendering purposes only and are to be confirmed at time of equipment submission.
1. **FUNCTIONAL PERFORMANCE**

1.1 **OPERATING RANGE**

1.1.1 The operation point shall be in the stable part of the curve.

1.2 **SAFETY**

1.2.1 Fan motor shall be non-overloading at any operating point.

1.2.2 Safety protection shall be provided for the motors as follows, unless otherwise specified:

   1.2.2.1 Single phase motors - Thermal overload protection.
   1.2.2.2 Three phase motors - Combined thermal overload and phase failure protection.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWN TIME**

2.1.1 Fans shall be so installed that replacement shall not take longer than 2 hours when executed by qualified building maintenance staff [Refer PART C4.7].

2.2 **DOCUMENTATION**

2.2.1 The Subcontractor shall submit service, maintenance, trouble shooting, testing, installation and start-up instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the equipment part of the 0 & M Manual [Refer Part C1.5 section 18].

3. **TECHNICAL RESTRAINTS**

3.1 Fan shall be complete with standard flanges on both sides for square type duct fans, and be suitable for standard size flexibles for round type duct fans.

3.2 Bearings shall be of the permanently lubricated type.

3.3 Fan assembly shall be statically and dynamically balanced at the manufacturer’s works within the design operating speed range.

3.4 Air flow arrow shall be installed.

3.5 Fan shall be direct driven, suitable for mounting at any angle and mounted on vibration isolation mountings.

3.6 Motor rating shall not be less than the maximum power required by the fan at any operating point between zero and break-off capacity.

3.7 Fan casing shall be insulated with high density acoustic insulation to limit break out noise to the occupied space.

3.8 The fan motor shall be provided with manually adjustable speed controller to deliver the specified air quantity.
4. BUILDING RESTRAINTS

4.1 Fan assembly shall be installed in accordance with manufacturer's recommendations.

4.2 Anchors that were not installed to the suppliers recommended procedures will not be accepted.

4.3 Washers shall be fitted to each nut and bolt.

5. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

5.1 Subcontractor shall supply the necessary field testing instruments and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ±5% for the Fan Acceptance Testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/table to confirm that claimed performance is achieved.

5.3 The various tests as required by the Quality Management System shall be demonstrated and accessible to the Engineer at all times for monitoring.

6. SCHEDULE

6.1 Refer layout drawings for schedules.

6.2 All figures given are for an altitude as specified in Part C3.1.

6.3 Pressure and absorbed power figures are for tendering purposes only and are to be confirmed at time of equipment submission.
1. FUNCTIONAL PERFORMANCE

1.1 This specification shall be read in conjunction with drawings.

1.2 Maximum allowable variation between actual air flow and specified air flow shall not exceed 5%.

1.3 Leakage shall not exceed 4% under operating conditions.

1.4 Ducting system shall attenuate the total sound power fed into the system by the fan to provide the specified noise levels in the spaces supplied by the ducting system either directly or indirectly (duct break-out and noise or air outlet noise).

1.5 SYSTEM OPERATION - OPERATOR INTERFACE

1.5.1 All isolating, fire, smoke and balancing dampers shall have external - easy accessible - position indicators, with locking and sealing means when required, and means of resetting after tripping.

1.5.2 Inspection doors shall be provided to inspect damper and/or equipment operation for which external indication is impossible or impractical.

2. RELIABILITY AND AVAILABILITY

2.1 DOWNTIME

2.1.1 Duct system control and safety equipment such as automatic dampers, booster fans, etc., requiring service and possible removal/replacement shall be installed in such a way that the downtime of the duct system does not exceed 1 hour when either service/repair or removal and re-installation is required [Refer PART C4.7].

2.2 DOCUMENTATION

2.2.1 Duct system control and safety equipment requiring service, maintenance, trouble shooting, periodic replacement, etc., shall be documented in accordance with the equipment part of the 0 & M Manual [Refer Part C1.5 Section 18].

3. TECHNICAL RESTRAINTS ON SYSTEM

3.1 The ducting system shall comply in all respects with:

3.1.1 SANS 1238 : 2005 "Standard Specification for Air Conditioning Ductwork"

3.1.2 SANS 10173 : 2003 "Code of Practice for the Installation, Testing and Balancing of Air Conditioning Ductwork".

3.1.3 Low Velocity Duct Construction Standards - SMACNA U.S.A.

3.1.4 SANS 10400 : 1990 * Section TT 43.2

3.2 Only proven minimum pressure loss fitting shown in the table, on page 2 of 7, with known loss co-efficient will be accepted on the project unless higher loss fittings are required, in certain locations only, to make the system self-balancing.
<table>
<thead>
<tr>
<th>NO</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>90° bend</td>
<td>Be equal to or greater than 0.75 (a)</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>90° bend with vanes</td>
<td>To be used if No. 1 is not feasible. Vane position in accordance with Figures 27, 28 &amp; 29 of SANS 1238 : 2005</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>90° take – off</td>
<td>Dimensions in accordance with Figure 34 and 35 of SANS 1238 : 2005</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Pyramidal diffuser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3 Additional sound attenuating elbows, attenuators, internal acoustic material to that shown on the tender drawings must be installed if a sound analysis, in accordance with Chapter 32 - Sound and Vibration Control - ASHRAE 1984 System's Volume, for the actual sound power generation of the selected fan, selected fittings and duct construction details indicate that this is required to maintain the specified noise level in the space.

3.4 Flexible ducting complete with insulation shall be constructed of non-combustible material as required in terms of the building regulations provided that:

3.4.1 Approved combustible flexible connections may be used where the length of such connection does not exceed 1.5m and such connection does not pass through any wall or floor which is required to have a specified fire resistance.

3.4.2 Where the 2nd fix position results in a longer flexible duct, circular ducting must be installed from the duct to the 2nd fix position to ensure a maximum flexible length of 1.5m.

3.4.3 Approved combustible flexible joints not more than 250mm in length may be used in any plant room where such plant room is protected by a smoke detection system.

3.5 Screws can be used as per SANS 10173 provided pilot holes are drilled through all layers of sheeting prior to inserting the screws.

3.6 Gripple type cable suspending system can only be used for the applications detailed in the table below:

<table>
<thead>
<tr>
<th>NO</th>
<th>DESCRIPTION</th>
<th>CIRCULAR DUCTING</th>
<th>RECTANGULAR/SQUARE DUCTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAIN DUCTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Externally insulated and un-insulated</td>
<td>Duct support as per SANS 10173 and support only can be suspended from trusses/soffit by gripple cable as per SANS 10173</td>
<td>Duct support as per SANS 10173 and support only can be suspended from trusses/soffit by gripple cable as per SANS 10173</td>
</tr>
<tr>
<td>2</td>
<td>FROM SPIGOT TO DIFFUSERS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Externally insulated</td>
<td>Duct support as per SANS 10173 and support only can be suspended from trusses/soffit by gipple cable as per SANS 10173</td>
<td>N/A</td>
</tr>
<tr>
<td>2.2</td>
<td>Un-insulated</td>
<td>Gripple cable around duct which can be suspended from trusses/soffit. As per SANS 10173</td>
<td>N/A</td>
</tr>
</tbody>
</table>
3.7 Circular ducting support details must comply with methods as indicated in details below:

**Note:**
1. Standard use of grippe cables remain as per S&P specifications, SANS 10173:2003 and SMACNA for “Uninsulated Ducting”.
2. When a concealed hanger support is used with wire cable, an eye bolt is required.
3.8 Fasteners of angle flange joints shall be spaced in accordance with the following table:

<table>
<thead>
<tr>
<th>FASTENER</th>
<th>SPACING BETWEEN CENTRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct G Clamp</td>
<td>300mm</td>
</tr>
<tr>
<td>Rivets, spot welds, bolts (Black steel ducting bolts only)</td>
<td>150mm</td>
</tr>
</tbody>
</table>

3.9 Fasteners of spigots, take-offs and shoes from main duct shall be spaced in accordance with the following table:

<table>
<thead>
<tr>
<th>FASTENER</th>
<th>SPACING BETWEEN CENTRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivets, spot welds and text screws</td>
<td>100mm</td>
</tr>
</tbody>
</table>

3.10 Fasteners of lobster bends, slip joints, stop ends and transformation sections shall be spaced in accordance with the following table:

<table>
<thead>
<tr>
<th>FASTENER</th>
<th>SPACING BETWEEN CENTRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot weld</td>
<td>150mm</td>
</tr>
</tbody>
</table>

3.11 Flexible canvas collars must align and have no strain after installed. The minimum clearance between two sections that is linked with a canvas collar is 30mm.

3.12 Flexible canvas collars must be covered with galvanised sheetmetal collar that is fixed to only one end of the collar. The remaining unfixed end must overlap the end of the flexible canvas collar with a minimum of 50mm.

3.13 All holes in support brackets must be drilled with drill to suite the size requirements of the hanger rod, U-bolt, etc and should not be oversized.
3.14 Low pressure rectangular ductwork shall comply with the relevant requirements. See table below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Longest side</th>
<th>Semi-perimeter</th>
<th>Minimum thickness</th>
<th>Maximum spacing between joints</th>
<th>Maximum spacing between stiffener</th>
<th>Joint type</th>
<th>Type of intermediate stiffener and joint stiffener</th>
<th>Slide-on flanges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 750</td>
<td>&lt; 1 150</td>
<td>0,6</td>
<td>2 400</td>
<td>2 400</td>
<td>“S” slip &amp; drive slip&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Sheet stiffener&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>&lt; 750</td>
<td>&gt; 1 150</td>
<td>0,6</td>
<td>2 400</td>
<td>2 400</td>
<td>Slip-on flange</td>
<td>Sheet stiffener&lt;sup&gt;a&lt;/sup&gt; Joint stiffener&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>751 to 1 350</td>
<td>-</td>
<td>0,8</td>
<td>2 400</td>
<td>1 500</td>
<td>Slip-on flange</td>
<td>Sheet stiffener&lt;sup&gt;a&lt;/sup&gt; Stiffener&lt;sup&gt;c&lt;/sup&gt;</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>1 351 to 2 000</td>
<td>-</td>
<td>1</td>
<td>1 500</td>
<td>1 500</td>
<td>Slip-on flange</td>
<td>Stiffener&lt;sup&gt;c&lt;/sup&gt;</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 2 100</td>
<td>-</td>
<td>1,2</td>
<td>1 500</td>
<td>1 500</td>
<td>Angle mild steel or slip-on flange and tie rods</td>
<td>Stiffener&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Mild steel angle 40x40x5</td>
</tr>
</tbody>
</table>

NOTE: For hangers refer to SANS 10173.

<sup>a</sup> Sheet stiffener – Either cross breaking, beading or pleating of longest side to be applied on all ducting where duct dimension is over 500mm.

<sup>b</sup> Joint stiffener – Refer to figures 9, 14 and 16 if required.

<sup>c</sup> 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).

<sup>d</sup> See figures 11, 12 and 13.

3.15 Uninsulated, bare ducting that is exposed to rain shall be cross bend with the highest point in the centre of the ducting where installed horizontally to prevent standing water.

3.16 All joints of ducting that is exposed to rain shall be sealed with waterproofing membrane to prevent water ingress.

4. **BUILDING RESTRAINT**

4.1 Ducting system must be isolated from actual or potential vibration generating equipment and building components to eliminate transmission of vibrations.

4.2 Anchors that were not installed to the suppliers recommended procedures will not be accepted.

4.3 Washers shall be fitted to each nut and bolt.
5. PRESSURE TESTING

5.1 Ducting shall be pressure tested as follows:

5.1.1 The duct pressure shall be at least 2 times maximum operating pressure, or 150 Pa, whichever is the greater.
5.1.2 Smoke shall be introduced into the duct section under test.
5.1.3 All leaks letting out visible smoke, shall be closed up with approved duct sealing compound.
5.1.4 A further pressure test shall be performed at the above specified duct pressure and leaks sealed until a maximum allowable leakage rate of 4% is reached, suitably de-rated for the volume handled by the duct section being tested.

5.2 Pressure testing shall be performed with the spigots installed, temporarily capped, but before the application of the external insulation.

5.3 This clause may be waived for the following duct work:

5.3.1 Duct work located in and supplying fresh air into an access floor plenum, or into a ceiling plenum.

6. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

6.1 The testing and balancing of the ducting system shall be executed under the control and supervision of an experienced testing and balancing engineer.

6.2 The method - instrumentation, procedure, recording shall be documented in a Testing, Balancing, Adjusting Procedure Book.

6.3 Minimum requirement for procedure, to be submitted for approval in accordance with contract conditions, SANS 10173 : 2003 and/or Procedural Standards - National Environmental Balancing Bureau and/or C.I.B.S. Code of Practice.

6.4 On completion of testing and balancing of the ducting system a signed report shall be submitted by the Subcontractor's Project Engineer listing all the results to prove that the system is balanced as specified.

6.5 Subcontractor shall submit proven and necessary calibration certificates that measurement have a 5% accuracy.
1. FUNCTIONAL PERFORMANCE

1.1 PERFORMANCE

1.1.1 The piping system shall provide the water flows, pressures and pressure drops specified on the schematic water piping diagram.

1.1.2 Maximum allowable flow variation for any terminal and/or connected equipment shall not vary more than ± 10% under maximum load design conditions.

1.1.3 Selection of equipment and capacity control valve pressure drop shall ensure stable capacity control operation without hunting of controls caused by ON-OFF effect; unless ON-OFF control is specified.

1.2 OPERATING RANGE

1.2.1 The final selection of equipment connected to the piping system, fittings, valves, etc (and if specified pump output control) shall ensure that the variation in water flow through connected equipment does not vary more than +20% between maximum and 10% water flow in water piping system.

1.3 SAFETY AND ALARMS - ABNORMAL CONDITIONS

1.3.1 Relief valves shall be installed in all closed piping system (or systems which can be closed) in easily accessible positions. The discharge of each relief valve shall be visible and piped to drain where discharge will not cause damage or injury.

1.4 SYSTEM OPERATION - OPERATOR INTERFACE

1.4.1 Hand wheels for valves shall be of a suitable diameter to allow tight closure by hand with the application of reasonable force, without additional leverage and without damage to stem, seat and disc. Hand wheel operated valves shall close CLOCKWISE, when looking on the face of the hand wheel. An arrow and the words "CLOSE" "TOE" shall clearly be cast or forged or stamped on the hand wheel to indicate the closing direction.

1.4.2 Valve shall be operable by personnel standing on the floor and/or permanent easy accessible platform.

1.4.3 All instruments installed for regular monitoring by Operator/Inspector shall be easily readable standing on floor with normal plantroom illumination.

1.4.4 All automatic control valves, change over valves, and balancing valves shall have easily readable position indicators when standing on plantroom floor.

1.4.5 All necessary pressure gauges, thermometer wells and thermometers shall be installed on the pipelines to check pressures and temperatures for monitoring the functioning of various components including possible blockage of strainers.

1.4.6 Flow meters and/or connections for portable flow meters shall be provided as shown.
2. RELIABILITY AND AVAILABILITY

2.1 DOWNTIME

2.1.1 Ring main piping shall be complete with all necessary isolating valves and drain valves, suitable for temporary drain connections, to enable repairs to be done to one section of the system without the necessity of shutting down and draining the remainder.

2.1.2 Components/equipment requiring regular inspections, cleaning and removal shall be isolated by shut-off valves to enable this to be done without draining the entire system.

2.1.3 Components shall be so connected and installed that removal and re-installation will not take longer than 2 hours by a qualified mechanic.

2.2 DOCUMENTATION

2.2.1 Water piping system control and safety equipment requiring service, maintenance, trouble shooting, and possible periodic replacement shall be documented in accordance with the equipment part of the Operating & Maintenance Manual. Refer Part C1.5 Section 18.

3. TECHNICAL RESTRAINTS

3.1 All sections, components, material, construction details/methods, installation procedures, etc for which SABS or BSS codes of practice or standard specification exist on date of tender, shall conform to these codes of practice/standard specifications.

3.2 Low-loss fittings, valves, bends, etc. as listed in the table on page 3 of 10, with the specified loss coefficient and meeting the listed standard specification on which pump system calculations have been based shall be used. The components shall be fully catalogued products and documentation shall include selection tables or pressure drop data for the expected range of operation conditions.
<table>
<thead>
<tr>
<th>Fitting</th>
<th>NOMINAL PIPE SIZE – mm</th>
<th>25</th>
<th>32</th>
<th>40</th>
<th>50</th>
<th>65</th>
<th>80</th>
<th>100</th>
<th>125</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>90° Long Radius Bend</td>
<td></td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>4.0</td>
<td>4.9</td>
<td>5.8</td>
<td>7.0</td>
<td>7.9</td>
</tr>
<tr>
<td>45° Standard Elbow</td>
<td></td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.6</td>
<td>2.0</td>
<td>2.4</td>
<td>3.0</td>
<td>4.0</td>
<td>4.9</td>
<td>5.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Flow Through Tee-Branch</td>
<td></td>
<td>1.5</td>
<td>2.1</td>
<td>2.4</td>
<td>3.0</td>
<td>3.7</td>
<td>4.6</td>
<td>6.4</td>
<td>7.6</td>
<td>9.1</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Flow Through Tee (No Reduction)</td>
<td></td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>4.0</td>
<td>4.9</td>
<td>5.8</td>
<td>7.0</td>
<td>7.9</td>
</tr>
<tr>
<td>Reducer (Smallest Pipe Size)</td>
<td></td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8</td>
<td>2.3</td>
<td>3.0</td>
<td>4.0</td>
<td>4.9</td>
<td>6.1</td>
<td>7.6</td>
<td>9.1</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Check Valve Swing Type</td>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>24</td>
<td>30</td>
<td>37</td>
<td>41</td>
<td>46</td>
</tr>
<tr>
<td>Diaphragm Valve</td>
<td></td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>18</td>
<td>23</td>
<td>26</td>
<td>31</td>
<td>42</td>
<td>49</td>
<td>55</td>
<td>62</td>
</tr>
<tr>
<td>Balancing Valve</td>
<td></td>
<td>11</td>
<td>17</td>
<td>22</td>
<td>31</td>
<td>33</td>
<td>39</td>
<td>60</td>
<td>60</td>
<td>110</td>
<td>160</td>
<td>200</td>
<td>300</td>
<td>500</td>
<td>800</td>
</tr>
<tr>
<td>Strainer</td>
<td></td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>18</td>
<td>23</td>
<td>26</td>
<td>34</td>
<td>46</td>
<td>50</td>
<td>58</td>
<td>65</td>
</tr>
</tbody>
</table>
3.3 Piping material and applicable standard specifications (amended as per Part C1.5 Section 5) for the different piping application shall be as stated in the following Table.

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>NOMINAL BORE mm</th>
<th>MATERIAL &amp; CLASS</th>
<th>APPLICABLE STANDARD</th>
<th>JOINTS</th>
<th>APPLICABLE STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLOSED CIRCUIT PIPEWORK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Dry coolers</td>
<td>200 to 600</td>
<td>Steel piping, grade B</td>
<td>SANS 719 : 2008 minimum wall thickness 6mm</td>
<td>Flanged joints.</td>
<td>SANS 62-2 : 2001</td>
</tr>
<tr>
<td>OPEN CIRCUIT PIPEWORK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser water to open cooling towers and evaporative coolers</td>
<td>As above using galvanised pipe and fittings up to 65mm dia.</td>
<td>As above using steel pipe and welded fittings 80mm dia and above, and hot dipped galvanized after manufacture to SANS 121:2011 Hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where specified in Job Spec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONDENSATE DRAINS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Fan coil units</td>
<td>25 to 65</td>
<td>As for open circuit pipework</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Air handling plants</td>
<td>80 to 200</td>
<td>As for open circuit pipework</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPRAY WATER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Evaporative coolers</td>
<td>20 to 65</td>
<td>Stainless steel Grade 304 Grade 314L</td>
<td>Stainless steel fittings of similar grade or welded.</td>
<td>Welding to manufacturers specification</td>
<td></td>
</tr>
<tr>
<td>. Humidifiers</td>
<td>20 to 65</td>
<td>Copper tube</td>
<td>Copper fittings compression or braze.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4 Piping maximum spacing of fixing shall be as stated in the following table:

3.4.1 Steel Piping

<table>
<thead>
<tr>
<th>TYPE OF PIPING</th>
<th>NOMINAL DIAMETER OF PIPE DN</th>
<th>SPACING ON HORIZONTAL RUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel conforming to BS EN 10312:2002(A)</td>
<td>Steel</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>250 and larger</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

3.4.2 Copper Piping

<table>
<thead>
<tr>
<th>TYPE OF PIPING</th>
<th>NOMINAL DIAMETER OF PIPE DN</th>
<th>SPACING ON HORIZONTAL RUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper confirming to temper designation R220 in Table 1 of BS EN 1057:2006</td>
<td>Copper</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>3.7</td>
<td></td>
</tr>
</tbody>
</table>
3.4.3 PVC Piping

<table>
<thead>
<tr>
<th>TYPE OF PIPING</th>
<th>NOMINAL DIAMETER OF PIPE DN</th>
<th>SPACING ON HORIZONTAL RUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC conforming to BS 6700 : 2006 +</td>
<td>15</td>
<td>0.85</td>
</tr>
<tr>
<td>A1 : 2009</td>
<td>20</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>2.2</td>
</tr>
</tbody>
</table>

3.5 The minimum gradient for water piping shall be one in 500 for venting and drainage.

3.6 Eccentric reducer sockets shall be used where necessary on horizontal runs of pipe and concentric sockets on vertical pipes.

3.7 Open or automatic air vents shall be provided at all high points in the system. The latter shall be preceded by stop valves. Automatic air vents in plant rooms located above 1 800mm shall be provided with outlet piped to visible discharge over drain.

3.8 The Subcontractor shall provide valves and caps, or drain at all low points in piping system, at bottom of each riser section and for each valved section of ring mains for draining.

3.9 All open end valves must be plugged.

3.10 Due allowance shall be made for venting sections of pipe being drained, both to enable drainage to be complete, and to prevent collapse due to internal vacuum.

3.11 Piping shall be installed so as to allow for expansion and contraction. Connections to coils, pumps and other equipment shall be made in such manner as to eliminate undue strains in piping and equipment. Necessary fittings and bends shall be furnished to avoid springing of pipes during assembly. Flexible connectors shall be provided where indicated, or if found necessary (see Clause 14 Part C3.2) and may also be required to bridge expansion joints in the structure.

3.12 All pipe welding shall be done by coded welder.

3.13 Arc welding shall be in accordance with SANS 15609-1:2007

3.14 The Subcontractor shall allow for one in ten welded pipe joints to be cut for examination purposes. If any of the welds prove unsatisfactory, the Subcontractor shall be called upon to have all welds examined by X-ray and to have X-ray plates examined by the SABS or other approved authority at his own expense.
3.15 HANGERS AND SUPPORTS

3.15.1 Refer special design - construction installation detail drawing.

3.15.2 Hangers for pipe supports are to comply with the Spoormaker support detail drawings. The Contractor may use BSS 3974 as a detail design guide for pipe support hangers. Where there is a conflict the Spoormaker support detail drawings take preference.

3.15.3 Pipes of small and medium bore shall be supported by means of compatible clamps, clips, holder bats or hangers in the manner and at the maximum spacing laid down in BS 6700.

3.15.4 Anchors and guides shall be provided for all horizontal and vertical piping for proper control of thermal movement and to prevent undue strain on branches and equipment and to provide proper performance of expansion joints and loops.

3.15.5 Additional steel framing for proper support, handling, anchoring and guiding of piping shall be used whenever required.

3.15.6 Hangers and supports shall be selected to support the full weight of piping, coverings and fluid conveyed.

3.15.7 Anchors that were not installed to the suppliers recommended procedures will not be accepted. Washers shall be fitted to each nut and bolt.

3.15.8 Pipe supports shall not be welded to piping at any time, even during construction.

3.15.9 All holes in support brackets must be drilled with drill to suit the size requirements of the hanger rod, U-bolt, etc. and should not be oversized.

3.16 FLEXIBLE HOSES

3.16.1 General

3.16.1.1 The hose is to be a seamless steel reinforced UV-resistant flexible hose with a protective and abrasion-resistant cover suitable for continuous use with a rated life of 15 years at the pressures, temperatures, environmental hazards and water velocities specified.

3.16.1.2 The hose shall be suitable for air conditioning applications.

3.16.1.3 The connection fittings shall be factory installed and permanently fixed to flexible hoses.

3.16.1.4 Hoses shall be SABS approved.
3.16.2 Pulsations

Over a 24 hour operating period the hose will be subjected to a 30 cycle stop start of water flow caused by the instantaneous opening and closing of a line size solenoid valve.

3.16.3 Water

The water carried by the hose is that commercially available from a supply authority. The water generally is retained in a closed circuit. The water is treated by various commercially available corrosion inhibitors. Metals in the closed circuit comprise mild steel, cast steel, stainless steel, cast iron, copper, brass and bronze.

3.16.4 Condensation

The temperature of the water carried by the hose is such that atmospheric condensation will occur on the outside of the hose and fittings. Contaminants found in the atmosphere and contaminants in normal air conditioned and ventilated buildings will be absorbed by and present in the condensation on the outside of the hose.

3.16.5 Working Pressure

The working pressure specified is the pressure exerted by the water inside the hose due to static head and pump pressure during normal flow conditions. It is not the pulsation pressure caused by the abrupt flow cessation when the downstream solenoid valve closes.

3.16.6 Test Pressure

The hose when subjected to an internal pressure of 3 times the specified working with a minimum of 1000kPa pressure and held for one minute before releasing to the working pressure and repeated for 30 cycles in a one hour period shall show no sign of, or indication of, failure.

3.16.7 Water Velocity

The water velocity inside the hose can vary between 1 and 5m/sec with a norm of 3m/sec.

3.16.8 Water Temperature

The temperature of the chilled water is normally 6°C but will vary between 5 and 30°C. The hose will be subjected to abrupt temperature changes and thermal shock from a no-flow situation with water at 30°C to a flow situation when solenoid valve opens with water at 5°C.

3.16.9 Ambient Temperature

The hose ambient temperature will vary between 12 and 30°C and is not normally subjected to direct sunlight.
3.17 SCREWED JOINTS

3.17.1 Screwed joints in steel piping shall be made with screwed socket joints using wrought-iron, steel or malleable cast-iron fittings.

3.17.2 A thread filler shall be used.

3.17.3 Hemp shall not be used in conjunction with any jointing paste.

3.17.4 Exposed threads left after jointing shall be painted or, where installed underground, thickly coated with bituminous or other suitable corrosion preventative in accordance with BS 5493:1977.

3.18 HOLES IN PIPING

3.18.1 Holes required in piping for stubs, take-off, etc must be drilled with appropriate size hole saw. No burning of holes with cutting torch is allowed.

3.19 FITTINGS AND INSTRUMENTATION ON PIPING

3.19.1 The sockets for instrumentation, valves, fittings etc. must be installed either on the side or the bottom of the pipe. No vertical take-off are allowed to ensure that any possible water ingress due to rain or condensation is limited and will run off the side/bottom of the pipe.

3.19.2 Position of stad/balancing must be installed as per suppliers specification.

3.20 PAINTING AND PROTECTION AGAINST CORROSION

3.20.1 All water distribution systems must comply to the painting and protection against corrosion requirements as requirements as specified in Part C3.2 Section 3.

4.0 MEASUREMENT TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

4.1 Full documentation and calculations shall be submitted for approval showing all detailed pressure loss and velocity calculations for the entire piping system and components both under full load and minimum load conditions.

4.2 The testing and balancing of the piping system shall be executed under the control and supervision of an experienced testing and balancing engineer.

4.3 The method - instrumentation, procedure, recording shall be documented in a Testing, Balancing, Adjusting Procedure Book.

4.4 The system shall be filled and air vented at least 24 hours before the actual test pressure is applied. The piping system shall be tested to a hydrostatic pressure of at least 1.5 times the maximum operating pressure but not less than 690 kPa (100 psi).

4.5 The system shall maintain the test pressure for a minimum period of 2 hours without pumping.
4.6 A satisfactory pressure test will not absolve the Subcontractor from responsibility for leaks which develop when the piping is operating under its normal working conditions, and also under any abnormal conditions which may reasonably be expected to occur.

4.7 On completion of testing and balancing of the piping system a signed report shall be submitted by the Subcontractor's Project Engineer listing all the results to prove that the system is balanced as specified.

4.8 Subcontractor shall submit proven and necessary calibration certificates that measurement have a 5% accuracy.
1. **GENERAL**

1.1 The Subcontractor shall supply and install the refrigeration piping system in accordance with the layout as shown on drawings.

1.2 The refrigerant piping system shall be designed and engineered in detail in accordance with the design criteria laid down in:-

1.2.1 Trane Reciprocating Refrigeration Manual 1977, and/or

1.2.2 Carrier Systems Design Manual - Piping Design - Chapter 3, Refrigerant Piping.

1.3 The refrigerant accessories shall be fully catalogued products and the documentation shall include performance curves or selection tables, for the expected range of operational conditions.

1.4 Submit certified detailed selection shown on these performance tables or curves.

1.5 Submit full documentation and calculations for approval of equipment submission, showing all detailed pressure loss and velocity calculations for the entire refrigerant piping system and accessories under full load and minimum load conditions, including the temperature/pressure curves and balance points for evaporator, compressor and condenser.

1.6 Where reduction in pipe size is necessary to provide sufficient gas velocity to entrain oil upwards in vertical risers at part load, and at full load the pressure drop exceeds specified design limits a double riser incorporating an oil trap will be necessary.

1.7 The system shall be designed: -

1.7.1 To minimise loss of lubricating oil from compressor at all times.

1.7.2 To ensure lubricating oil return to compressor, at the same rate at which it leaves under all load conditions.

1.7.3 To prevent lubricating oil being trapped in system.

1.7.4 To prevent liquid refrigerant from entering the compressor during operation and shutdown.

1.7.5 For minimum pressure drop and noise generation. The suction, discharge and liquid lines shall be sized so that the pressure drops shall not cause a change in saturation temperature of refrigerant greater than 1.1 degrees C in each respective line.

1.7.6 For handling the specified capacity from 100% down to minimum load at specified suction and discharge/condensing temperature.

1.8 Refrigerant piping accessories and connections shall be selected to ensure no leakage from refrigerant piping system during its operational life.

1.9 Refrigerant piping system shall be complete with all necessary isolating valves to enable repairs and maintenance to be carried out on any one section of the system.

1.10 The refrigerant accessories shall be so connected and installed into the refrigerant piping system that either a sub-component replacement or total removal and reinstallation of the accessory shall not take longer than 2 hours by qualified refrigeration mechanics.

1.11 Piping system, including accessories, thermal insulation, hangers, supports and vibration isolators shall be selected and installed to give a minimum working life of 15 years under normal building service conditions.

1.12 The entire refrigerant system shall be subjected to a leak pressure test with a suitable gas, e.g. clean dry air or nitrogen.
1.13 For this test it is permissible to add system refrigerant to enable leakages to be more easily detected.

1.14 Prior to carrying out this test the Subcontractor shall verify by examination of the various parts of the components of the system that the test pressure to which they were subjected at the manufacturer's works, are adequate for the required duties.

1.15 A safety valve or rupture disc shall be incorporated in the piping system.

1.16 Rupture discs shall have a specified and certified bursting pressure at a specified temperature and shall be marked on the disc.

1.17 The system shall comply with the Safety Code for Refrigerant Piping ASA B31.35 - 1962 with the requirements of ASME, with Occupational Health and Safety Act, as amended, and with local authorities by-laws. Refer Part C1.5 Section 5.

1.18 Piping shall be stored and handled on site to prevent dirt from entering piping system. Open ends shall be plugged.

1.19 Tubing shall be protected against oxidation during silver soldering by use of dry nitrogen flowing through tubing. Solder shall be silver solder.

1.20 Where required for connection to gauges and control devices, tubing not larger than nominal 10 mm, may be type K soft (annealed) with flared tube fittings suitable for high pressure.

1.21 Accessories connected to copper tubing shall have solder type ends or flanged ends and soldered flange adaptors.

1.22 Piping shall be installed so as to allow for expansion and contraction. Suction and discharge lines shall be installed so that the first point of support is 6 pipe diameters in each of three directions from the unit.

1.23 System vibration isolation shall be in accordance with Sound and vibration Control. (Refer Part C3.2 Section 5).

1.24 Thermal insulation of suction line shall be in accordance with insulation. (Refer Part C3.2 Section 4).

1.25 Piping shall be installed parallel or perpendicular to building construction, while maintaining the required gradients.

1.26 Refrigerant piping between indoor and outdoor units shall be supported along its entire length by a proper galvanised tray of sufficient size to allow pipework to be neatly laid out and insulated. The cable tray to be supported clear of fixing surface by galvanised brackets allowing air space between cable tray and mounting surface. The refrigerant piping shall not be fixed to the underside of the cable tray.

1.27 Where piping and insulation is exposed to damage or located externally to the building, a galvanised trunking with removable sheet metal cover having a minimum thickness of 0.8mm shall be neatly formed and secured to the brackets. Joints to be lapped by a minimum of 30mm and to have a minimum clearance of 10mm over insulation.

1.28 Piping and/or electrical wiring shall not cross or lie on top of each other

1.29 Wire basked shall not be used to support refrigerant piping

1.30 Where a galvanised sheetmetal cover cannot be installed the exposed refrigerant piping must be wrapped with UV resistant waterproofing membrane and painted to an approved colour.

1.31 Where cable ties are used around insulated refrigerant piping care shall be taken not to damage the insulation when tightening the cable ties.

1.32 Insulation joints shall be glued with ends to ensure vapour barrier.

1.33 Anchors that were not installed to the suppliers recommended procedures will not be accepted.

1.34 Washers shall be fitted to each nut and bolt.
All necessary pressure gauges shall be installed on and in refrigerant lines to check pressures and temperatures for load monitoring, function of various accessories and possible blockages of strainers.

Accessories requiring regular inspection, cleaning and removal shall be isolated by shut-off valves to enable this without pump down of the entire refrigeration system.

2 ACCESSORIES

2.1 LIQUID RECEIVERS

2.1.1 Each receiver shall have sufficient capacity to hold all refrigerant in the system to which it is connected, except that in plants having two or more separate refrigerant circuits, cross connected by pump out piping, the receiver shall have sufficient capacity to hold all refrigerant in the largest circuit. Receiver capacity shall be based on not over 85% of its internal volume being occupied by liquid. Receiver to be complete with liquid level indication.

2.2 LIQUID SUCTION INTERCHANGER

2.2.1 Heat exchangers for field assembled systems shall be the standard products of a reputable manufacturer. Field fabrication of heat exchangers will not be permitted.

2.2.2 Heat exchangers for field assembled systems shall be of the shell and tube, shell and coil or double tube type. Tubes shall be seamless copper, plain or with integrated fins. Shells shall be welded steel, conforming to the requirements of the latest edition of the Mines and Works Act or the Machinery, Factories and Building Work Act and Regulations, covering pressure vessels. Gas passages shall be arranged so as to prevent trapping of oil. Liquid pressure drop shall not exceed 21 kPa and gas pressure drop shall not exceed 3.5 kPa.

2.3 REFRIGERANT DRIERS

2.3.1 Refrigerant driers for field assembled systems shall be of the angle type with removable cartridges that can be renewed without disturbing pipe connections. Driers shall have brass or steel bodies and solder joint connections. Bonnets shall be flanged and bolted. Cartridges shall be charged with dry silicagel or activated alumina, held securely in place without restraining normal expansion, and provided with suitable means for distributing the refrigerant evenly through the charge. Unless otherwise indicated driers shall be installed in liquid lines close to the receiver outlets and shall be provided with valves on the inlet and outlet connections. Valved by-passes shall also be provided unless the driers are of a type guaranteed by the manufacturer to operate indefinitely without dusting of the desiccant or appreciable increase in pressure drop. A liquid sight glass and moisture indicator of the colour change type shall be installed in the liquid line, close to each drier.

2.3.2 Each drier shall be so selected that the pressure drop through the drier shall not exceed 14 kPa when operating at full connected evaporator capacity.

2.3.3 Drier cartridges shall not be installed until after pressure and vacuum tests have been completed but immediately prior to charging.

2.4 THERMOSTATIC EXPANSION VALVES

2.4.1 In field assembled systems, each evaporator circuit shall be provided with a thermal expansion valve of the gas charged type. Valves shall have external equalizer connections, external superheat adjustments with seal caps and solder joints or flanged pipe connections. Valves shall require not more than 3 degrees C superheat change to move from fully open to fully closed. Superheat setting shall be 6 degrees C at full load. Each valve shall be provided with an external strainer, regardless of any internal strainer that may be incorporate in the construction. Strainers shall be as specified under "Refrigerant Strainers".
2.5 OIL SEPARATORS

2.5.1 Each reciprocating compressor having suction and/or liquid mains more than 15 m long shall be equipped with a discharge line oil separator.

2.5.2 Separators shall be made of welded steel and shall have an effective impingement type separating element, an oil sump and a float operated return trap connected to return oil to the compressor automatically.

2.6 REFRIGERANT STOP AND SHUT-OFF VALVES

2.6.1 Refrigerant stop valves shall be provided on all DX installation over 18kW (ISO) in cooling capacity and shall be of the back seating key operated, sealed cap type. Valves which must be opened and closed in regular operation shall have hand wheels and shall be of the packless type.

2.7 REFRIGERANT STRAINERS

2.7.1 Refrigerant strainers shall be of the angle type, cleanable without disturbing pipe connections. 40 mm N.B. strainers and smaller shall have brass bodies and solder joint connections and 50 mm N.B. strainers and larger shall have brass or rust proofed steel or iron bodies and flanged connections. Connections shall be flanged and bolted.

2.7.2 Screens shall be bronze metal with perforations not larger than 0,25 mm for liquid lines and 0,5 mm for gas lines. The free area of each screen shall not be less than 5 times the area of the strainer inlet pipe.

2.8 CHARGING VALVES

2.8.1 Charging valves shall be located into the liquid line between the receiver shut-off valve and expansion valve.

2.9 GAUGE VALVES

2.9.1 External gauge connections to be provided at inlet and outlet of condenser, evaporator coil and compressor for evaluation of system pressures at commissioning and for normal maintenance inspections.

2.10 GAUGES

2.10.1 All gauges shall be connected to the refrigerant and piping system, through isolating shut-off valves.

2.11 LIQUID INDICATORS

2.11.1 A sight glass of full size shall be provided on all DX installation over 18kW (ISO) in cooling capacity in the main liquid line before the thermostatic expansion valve and shall be of the double port with seal cap type.

2.12 SOLENOID VALVES

2.12.1 The solenoid valves shall have manual override to enable the system to continue to operate in case of solenoid coil failure.

2.13 VIBRATION ISOLATORS: FLEXIBLE CONNECTORS

2.13.1 Suction and discharge lines from the compressor shall be fitted with flexible connectors of the bronze braided hose type, having sweat-ends, to fit over copper tubing having the same size as the line in which they are installed.

2.13.2 Each flexible connector shall be located as close as possible to the compressor and parallel to the compressor shaft.

2.13.3 It shall not be subjected to compression or extensions.

2.13.4 For refrigeration installation utilising a remote air cooled or evaporative condenser, hot gas mufflers shall be used to remove pulsations from the hot gas discharge and thereby reduce noise and vibration from the piping system. The hot
gas muffler must be installed to prevent accumulation of oil.

3. TESTING CHARGING EVACUATION

3.1 TESTING

3.1.1 Complete system to be pressure tested with dry nitrogen and leak test carried out. Test pressure to be maintained for 24 hours with no loss in pressure.

3.2 EVACUATION

3.2.1 Complete system to be evacuated and proved to be free of moisture. System to stand for a minimum of 12 hours with no change in Vacuum.

3.3 CHARGING

3.3.1 System to be liquid charged on high side following purging of connections to the estimated total charge. Minor adjustment to charge to be carried out during the 72 hour test run.
1. GENERAL

The installation of cables in buildings, and in the ground for system voltages up to 11000 volts, 50Hz, shall conform to the following standards:

A. SANS 10142-1
B. SANS 10142-2
C. SANS 1507
D. SANS 97
E. SANS 1339
F. SANS 10198 part 1 to 13

Please note that all amendments published at the time of tender shall be applicable.

1.1 CABLE TYPES

1.1.1 The following cable types shall be used, unless otherwise specified in the detailed technical specification:

1.1.1.1 Medium voltage supplies (6600/11000 Volts):
   Paper insulated, lead covered, steel armoured, screened and drained (general use), manufactured to SANS 97 (table N)
   or
   Cross-linked polyethylene (XLPE) with copper conductors and screened with a brass sheath manufactured to SANS1339.

1.1.1.2 Low voltage:
   PVC insulated steel wire armoured manufactured to SANS1507, Low Halogen Type.
   Un-armoured PVC insulated cables may only be used if specified in the detail specification and measured in the bills of quantities.

1.1.1.3 Connections to equipment:
   PVC insulated steel wire armoured or unarmoured when installed in conduit or metal trunking. Cable bending radius shall be as specified in SANS 10142-1.

1.1.2 All cables supplied shall have the following information on the cables:

1.1.2.1 Every meter the length of a cable shall be visible
1.1.2.2 The size of the cable shall be marked on the cables
1.1.2.3 The applicable SANS number to which the cable complies with

1.2 CABLE TAGGING

1.2.1 All cables shall be identified at each termination by means of punched metallic bands or engraved PVC tags cable tied to cable. PVC tape with printed characters will not be accepted.

1.2.2 The following shall appear on the cable tags:

1.2.2.1 At point of supply:
   Cable voltage, Cable size, Cable type, and Supply to DB-XXX – Normal/Emergency/UPS Section or equipment name e.g. 11kV, 70mm² 4 Core XLPE – Supply to Transformer 1

1.2.2.2 At point of consumption:
   Cable voltage, Cable size, Cable type, and Supplied from DB-YYY – Normal/Emergency/UPS Section e.g. 400V, 95mm² 4 Core PVC – Supply from DB-MLV
1.2.3 Identification numbers of cables shall be shown on the "as built" drawings of the installation.

1.3 TESTING

1.3.1 Each cable shall be tested after installation in accordance with SANS 1507 and SANS 97 and SABS 1339 (up to 11kV) as well as the requirements of the Local and Supply Authorities.

1.3.2 The minimum acceptable insulation resistance values for the cables shall be calculated as follows:

\[ R_{\text{insulation}} = (V_{\text{Rated}} + 1) \times \left( \frac{304.8}{L} \right) \]

Where:
- \( R_{\text{insulation}} \) is the Minimum acceptable insulation resistance value, in mega-ohms
- \( V_{\text{Rated}} \) is the rated voltage of the cable, in kV

1.3.2.1 LV Cables

LV cables shall be tested by means of a suitable insulation resistance tester at 2,000V (RMS) or 3000V (dc) for a period of 15min and the insulation resistance shall be tabulated and certified.

1.3.2.2 MV Cables

New PILC cables may be tested using DC voltages as per the table below, however existing PILC cables shall be tested using VLF testing – Test voltages are as per table 1.

XLPE cables shall be tested as using VLF Testing – Test voltages are as per table 1.

<table>
<thead>
<tr>
<th>Cable Rating (kV)</th>
<th>TEST VOLTAGE (Applied for 15 Minutes)</th>
<th>New Paper-insulated cables</th>
<th>XLPE-insulated cables &amp; Existing PILC Cables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between conductors</td>
<td>Conductors to sheath</td>
<td>Conductors to screen</td>
</tr>
<tr>
<td>6.6</td>
<td>AC RMS (kV)</td>
<td>DC (kV)</td>
<td>AC RMS (kV)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 1

1.3.3 MV cables shall be pressure tested in accordance with the above Table and the exact leakage current shall be tabulated and certified.

1.3.4 The Contractor shall make all arrangements, pay all fees and provide all equipment for these tests. The cost of testing shall have been included in the tender price.

1.3.5 The Contractor shall notify the Engineer and if applicable the Supply Authority at least 7 days prior to the tests so that their representatives may witness the tests.

1.3.6 On Completion of the tests on any cable, the Contractor shall without delay, submit three copies of the certified Test Reports to the Engineer.

1.3.7 The contractor shall provide all the testing equipment as required for the respective tests.
1.4 JOINTS

1.4.1 Jointing shall be carried out strictly in accordance with the manufacturer's instruction and by personnel competent in jointing the types of cables involved.

1.4.2 No joints in cable runs will be allowed unless a cable run exceeds the maximum length available on a cable drum. (Normally 300 m)

1.4.3 The joint shall not impair the anti-electrolysis characteristics of the cable.

1.4.4 Joints shall be fully water and air tight and shall be free of voids and air pockets.

1.4.5 The crossing of cores in joints will not be permitted under any circumstances.

1.4.6 The Contractor shall notify the Engineer timeously of the day on which jointing is to be carried out in order that an inspection may be arranged if so required. Any cable joint not inspected by the Engineer because of insufficient notice being given, shall be opened for inspection and redone at the discretion of the Engineer and at the cost of the Contractor.

1.4.7 Outdoor termination must be able to withstand air pollution and bad weather without any signs of surface current tracking.

1.4.8 Termination for high voltage cables must have a satisfactory stress relief in order to keep the partial discharges extinguished.

1.4.9 Taped or prefabrication terminations may be used, in accordance with the manufacturer's recommendation.

1.5 CONNECTION OF CABLE CORES

1.5.1 When cutting away insulation from cable cores to fit into lugs, care shall be taken that no strands are left exposed. Under no circumstances may any of the conductor strands be nicked or cut away to fit into lugs.

1.5.2 Contact surfaces shall be thoroughly cleaned and smoothed and fixing bolts shall match the hole size of the lug.

1.5.3 Suitable lugs shall be crimped to cable core ends using mechanical or pneumatic tools designed for this purpose.

1.5.4 Cables that are connected to clamp type terminals where the clamping screws are not in direct contact with the conductor, need not be lugged but the correct terminal size shall be used.

1.5.5 Ferrules shall be used where cable cores are connected directly to equipment with screws against the conductor strands.

1.6 TRENCHING

1.6.1 The Contractor shall, before trenching commences, familiarise himself with the routes and site conditions. The procedure and order of doing the work shall be coordinated with the general construction programme.

1.6.2 The Contractor shall acquaint himself with the position of all the existing electrical, civil and other services before excavation is commenced.

1.6.3 The Contractor will be held responsible for damage to any such existing services and shall be responsible for the cost of repairs.

1.6.4 The Contractor shall ensure that the excavations will not endanger existing building structures, roads, railways, other site constructions or other property before excavating.
1.6.5 The Contractor shall take all the necessary precautions and provide the necessary warning signs, barricades and/or lights to ensure that the public and/or personnel on site are not endangered.

1.6.6 Trenches crossing roads, footpaths or access ways shall not be left uncovered. If cables cannot be laid immediately the Contractor shall install temporary cover plates etc., of sufficient strength to accommodate the traffic concerned.

1.6.7 The bottom of the trench shall be smooth and free of any sharp dips or rises which may cause tensile forces in the cable during backfilling.

1.6.8 The nature of the soil that can be encountered is classified as follows:

1.6.8.1 Very hard rock shall mean rock that can only be excavated by means of explosives.

1.6.8.2 Hard Rock shall mean granite, quartzitic sandstone, slate and rock of similar or greater hardness, solid shale and boulders over 0,03 cubic metre in volume.

1.6.8.3 Soft rock shall mean rock that can be loosened by hand-pick and includes hard shale, compact gravel stone and rocks from 75mm in diameter up to 0,03 cubic meters in volume.

1.6.8.4 Soil shall mean ground that can be removed by pick and hand shovel and includes loose gravel, clay, made-up ground, loose or soft shale, loose gravel stone and rocks less than 75 mm in diameter.

1.6.9 Should blasting be necessary, the Contractor shall obtain all necessary authorities from the relevant Departments and Local Authorities. The Contractor shall take full responsibility and observe all conditions and regulations set forth by the above Authorities.

1.6.10 The necessary insurance cover must be obtained to cover possible damage and losses.

1.6.11 Blasting shall be subject to the approval of the Engineer.

1.7 CABLE SLEEVES

1.7.1 Where cables cross under roads, railway tracks, other service areas, etc. and where cables enter buildings, the cables shall be installed in hard walled PVC or earthenware pipes. Road and railway crossings shall be done at right angles.

1.7.2 Sleeves shall have a minimum diameter as specified and shall extend at least 1,0 m beyond the road edge or kerb on either side of the crossing.

1.7.3 After the installation of cables, the ends of all sleeves shall be sealed with a non-hardening watertight compound. All sleeves intended for future use shall likewise be sealed.

1.7.4 Where sleeves have to be built into structures by others, the Contractor shall supply the sleeves and ensure that they are installed correctly.

1.8 CABLE INSTALLATION AND BACK FILLING

1.8.1 Before the cable is laid into the trench the bottom of the trench shall be filled across the full width with a 75 mm layer of suitable sifted soil and levelled off. After cable laying a further layer of bedding shall be provided to extend to 75 mm above the cables.

1.8.2 If there is no suitable soil available on site, the Contractor shall import fill and make all the necessary arrangements to do so. The cost of importing soil for bedding purposes shall be included in the rates for excavations.
1.8.3 The bedding under joints shall be fully consolidated to prevent subsiding.

1.8.4 The Contractor shall not commence with the back filling of trenches before the Engineer has inspected the cable installation. Should the Contractor fail to give a timeous notification, the trenches shall be re-opened at the Contractor's cost. Such an inspection will not be unreasonably delayed.

1.8.5 Cables (1000V to 11000V) shall be provided with a yellow coloured plastic marking tape installed 400 mm above the cable. The tape shall be marked with a red skull and crossbones with the words "Electric Cable". This marking shall be installed over the entire length of the cable.

1.8.6 The maximum accepted diameter of stones present in the back fill material is 75 mm.

1.8.7 The back fill shall be compacted in 150mm layers and sufficient allowance shall be made for final settlement. The Contractor shall maintain the refilled trench at his expense for the duration of the contract. The surface shall be made good to the same density and to match the surrounding areas on completion.

1.8.8 In the case of road ways or paved areas the excavations shall be consolidated to the original density of the surrounding material and the surface finish reinstated.

1.9 CABLE MARKERS

1.9.1 Cable markers shall consist of concrete blocks dimensioned as follows:

1.9.2 300mm high, 150mm x 150mm at the top and 250mm x 250mm at the bottom.

1.9.3 A brass plate for labelling shall be cast into the tops of the blocks in such a manner that they cannot be prised loose. The wording as follows as well as arrows indicating cable direction shall be clearly stamped on the brass plates.

1.9.3.1 For HV cable route - "HIGH VOLTAGE CABLES".
1.9.3.2 For MV and LV cable routes - "ELECTRICAL CABLES"
1.9.3.3 For joint positions - "ELECTRIC CABLE JOINT".

1.9.4 Cable markers shall be installed on the surface along all the underground routes and shall project 50 mm above finished or natural ground level. If the projected markers could be a hazard to pedestrians or other traffic, they shall be installed flush with the surface.

1.9.5 Cable markers shall be installed at all changes of direction, at the beginning and end of cable runs (i.e. where a cable enters a substation or building), above all joints above cable pipe entries and exits and at intervals not exceeding 50m along the cable route. The position of cable markers shall be indicated on the "as built" drawings.

1.10 PROVINCIAL ADMINISTRATION, NATIONAL ROAD AND S.A.R. CROSSINGS

1.10.1 The Contractor shall conform with the various Administrations' requirements with regard to the crossing of Provincial and National roads, especially with regard to safeguarding of the public and traffic control. The Contractor shall also provide proof of adequate insurance cover against any claim from any accident as a result of work done by the Contractor during the crossing operation. The Owner shall be indemnified from all liability in this regard.

1.10.2 The Contractor shall liaise with the various Administrations and Traffic Departments etc., well in advance regarding the intended dates, times and expected duration of the crossing operations and obtain their approval of the programme and method of operation before work is commenced.

2 INSTALLATION OF CABLES

2.1 INSTALLATION DEPTHS IN GROUND
2.1.1 All cables laid directly in the ground shall be laid at a depth such that the vertical distance from the top of the cable to the ground surface is not less than the values given below:

<table>
<thead>
<tr>
<th>Cables in open ground or under pedestrian paved areas</th>
<th>HV Cables</th>
<th>MV &amp; LV Cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Sites</td>
<td>750 mm</td>
<td>450 mm</td>
</tr>
<tr>
<td>Industrial and Commercial Sites</td>
<td>1 000 mm</td>
<td>600 mm</td>
</tr>
<tr>
<td>Road Crossings</td>
<td>1 100 mm</td>
<td>1 100 mm</td>
</tr>
<tr>
<td>Railway Crossings</td>
<td>1 500 mm</td>
<td>1 500 mm (From top of sleepers)</td>
</tr>
</tbody>
</table>

2.1.2 Cables shall not be laid direct in the ground if any corrosive agent is found to be present.

2.1.3 Before cable laying is commenced, all cable trenches shall be drained, the bottoms graded and compacted and all loose stones and similar debris removed.

2.1.4 Cable trench width for one or two cables shall be a minimum of 550 mm. The width shall be increased as more cables are installed allowing for at least two cable diameters spacing for each cable added.

2.2 CABLE LAYING

2.2.1 Cable rollers shall be used at all times to run out cables. Rollers shall be spaced so that the length of cable will be totally suspended during the laying operation.

2.2.2 Where cables have to be drawn through pipes or ducts, a suitable cable sock shall be used and care shall be exercised to avoid abrasion, elongation or distortion of any kind.

2.2.3 Where cables have to be drawn around corners, well lubricated securely fixed skid plates shall be used. CABLES SHALL BE PULLED INTO TRENCHES ETC., BY HAND ONLY.

2.3 SPACING OF CABLES IN GROUND

2.3.1 Cables installed in a common trench shall be laid parallel to each other spaced as follows: (LV: up to 1000V; HV: 1000V to 11000V):

2.3.1.1 LV/LV : 2 cable diameters
2.3.1.2 LV/HV : 300 mm minimum

2.3.2 Where HV and LV cables have to be installed in the same trench, the HV cable shall be laid on the one side of the trench at a depth as specified in 2.1 and then covered with soil. The LV cable shall then be laid on the other side of the trench at the depth specified in item 2.1.

2.3.3 Cables shall not be buried on top of each other unless layers are specified. The minimum spacing between layers shall be 200 mm.

2.3.4 Cables for telephones, communication systems and other low voltage systems (less than 50V) shall be separated from power cables by at least 1000mm. All control or pilot cables shall be laid at least 300mm from power cables.

2.4 CABLE BENDING RADIUS

Please refer to the table below for the minimum cable bending radius:
### 3 INSTALLATION IN BUILDINGS

#### 3.1 GENERAL

3.1.1 Particular attention shall be paid to the application of grouping factors in respect of current rating and the appropriate spacing of cables shall be allowed.

3.1.2 Cables for services above 650 volts shall be run separately from all other cables with a minimum clearance of 2300 mm. Cables for service below 100 volts including sound and telephone systems shall also be segregated from all other cables.

3.1.3 All cables shall be adequately supported throughout their length as specified by the Wiring Regulations or, where not specified as recommended by the cable manufacturers. No joints shall be allowed in cables of less than 300 m length, unless as specified or specifically approved.

#### 3.2 CABLE FIXINGS ABOVE FLOOR LEVEL

3.2.1 On Cable ladders:

3.2.1.1 Cables shall be secured to the cable ladder by means of minimum 12.7 mm cable ties at intervals not exceeding 1500 mm for horizontal runs and 750 mm for vertical runs.

3.2.2 Mounted on unistrut supports:

3.2.2.1 The intervals of the supports shall be such that no cable sagging occurs, but minimum interval shall be 750 mm. Cables shall be secured with the appropriate size cable K or U clamp onto the unistrut support.

3.2.2.2 Mounting directly onto wall

3.2.2.3 Appropriate cable saddles shall be used to secure the cable to the wall, at minimum 750 mm intervals.

3.2.2.4 Single core cables comprising of three phase circuit shall be laid throughout in trefoil formation, each cable touching. They shall be fixed with hardwood blocks or purpose made cleats supported on steelwork or proprietary rails segregated from all other cables and located in a protected situation.
3.3 CABLES IN CONCRETE TRENCHES

3.3.1 In concrete trenches cables shall be laid side by side on the bottom of the trench without cross-overs. When necessary to maintain spacing factors cables shall be fixed to the sides of the trench using cleats as specified for installation above floor level.

3.4 CABLES IN DUCTS

3.4.1 The total cross sectional area of all cables installed in a duct shall not exceed 50% of the internal cross sectional area of the duct. After installation of the cables, duct stops shall be fitted to each end of each duct run and at the entry to the building to effectively seal the duct from ingress of vermin, etc.
1. GENERAL

This specification covers the design, manufacturing, and installation and testing of factory built distribution boards, motor control centres and outdoor kiosks.

2. STANDARDS

Factory built distribution boards and motor control centres shall comply with the following standards:

A. SANS 10142-1
B. SANS 1973-1, 3 and 8
C. SANS 60439-1 to SANS 60439-5
D. SANS 61439-1 to SANS 61439-6
E. SANS 60529
F. Occupational Health and Safety Act 85/1993

Please note that all amendments to these standards published at the time of tender shall be applicable.

3. CONSTRUCTION

3.1 GENERAL REQUIREMENT

3.1.1 The manufacturer shall design the distribution board based on the single line diagram provided by the engineer to ensure that all switchgear and control gear can be fitted within the enclosure with 30% spare space for future additions without the need to change the assembly construction. The unused spaces shall be covered by means of blanks to ensure that the IP rating of the assembly remains intact.

3.1.2 As a minimum the assemblies with the fault levels as stated shall comply to the following standards:

3.1.2.1 fault level ≤ 10kA shall comply with SANS1973-3
3.1.2.2 fault level > 10kA with operating current less than 1600A – SANS 1973-8 (Only if specified)
3.1.2.3 fault level > 10kA shall comply with SANS1973-1 / SANS60439 / SANS61439

3.1.3 All enclosures or partitions including locking means and hinges for doors shall be of sufficient mechanical strength to withstand all mechanical stresses to which it may be subjected to during normal and short circuit conditions.

3.1.4 Prior to construction the manufacturer shall submit general arrangement drawings containing the following:

3.1.4.1 Physical size, i.e. height, width and length
3.1.4.2 Weight
3.1.4.3 Transport section
3.1.4.4 Rated operating voltage
3.1.4.5 Rated insulation voltage
3.1.4.6 Rated operating current
3.1.4.7 Rated short time withstand current
3.1.4.8 IP rating
3.1.4.9 Detail control diagrams
3.1.4.10 Schedule with make, model and rating of all switchgear and control gear
3.1.5 All switchgear and control gear used within the assembly shall comply with Section IV.6 of this specification. The manufacturer needs to ensure that the selection of the co-ordination of the protective devices are done to ensure selectivity of the protective system and needs to be proven by the supplier of the protective equipment.

3.2 ELECTRICAL CHARACTERISTICS

3.2.1 All assemblies shall have the following electrical characteristics:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SINGLE PHASE ASSEMBLIES</th>
<th>THREE PHASE ASSEMBLIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rated operating voltages</td>
<td>231V</td>
<td>400V</td>
</tr>
<tr>
<td>The rated insulation voltage</td>
<td>1000V</td>
<td>1000V</td>
</tr>
<tr>
<td>The Rated Impulse withstand voltage</td>
<td>6000V</td>
<td>6000V</td>
</tr>
<tr>
<td>Rated Frequency</td>
<td>50Hz</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.2.2 The rated current and rated short time withstand current shall be as noted on the single line diagrams.

3.2.3 The minimum creapage and clearance distances shall be as follows:

<table>
<thead>
<tr>
<th>PHASE TO PHASE</th>
<th>PHASE TO EARTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance in Air</td>
<td>8</td>
</tr>
<tr>
<td>Creepage distance</td>
<td>16</td>
</tr>
</tbody>
</table>

3.3 MATERIAL

3.3.1 Assemblies shall be constructed only of materials capable of withstanding the mechanical, electrical and thermal stressses as well as the effects of humidity. The minimum thickness of the galvanised / alloy cold rolled zinc steel that will be used is 2mm, unless the rigidity of a thinner material can be demonstrated.

3.3.2 The enclosure shall be protected against corrosion by applying a suitable coating on the exposed surfaces.

3.3.3 All metal parts shall be externally and internally prepared for painting in accordance with SANS 10064, thereupon treated with baked enamel primer, and finally finished in an infra-red baked enamel, in the colour externally called for in the Detail Specification and the minimum thickness of the finished product shall be 85µm.

3.3.4 Assemblies can be wall mounted, free standing with front access only or free standing with front and rear access.

3.3.5 For panels with front access only, a cable way of at least 400mm shall be provided where practical possible.
3.3.6 The gland plates shall be galvinsed and at least 3mm thick and shall be bonded to the main earth bar by means of copper conductor in accordance with the table below:

<table>
<thead>
<tr>
<th>RATED OPERATIONAL CURRENT $I_e$</th>
<th>MINIMUM CROSS SECTIONAL AREA OF THE PROTECTIVE / BONDING CONDUCTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_e \leq 20\text{A}$</td>
<td>Same as the phase conductor</td>
</tr>
<tr>
<td>$20\text{A} &lt; I_e \leq 25\text{A}$</td>
<td>2.5mm²</td>
</tr>
<tr>
<td>$25\text{A} &lt; I_e \leq 32\text{A}$</td>
<td>4mm²</td>
</tr>
<tr>
<td>$32\text{A} &lt; I_e \leq 63\text{A}$</td>
<td>6mm²</td>
</tr>
<tr>
<td>$63\text{A} &lt; I_e$</td>
<td>10mm²</td>
</tr>
</tbody>
</table>

3.3.7 Gland plates and cable support bars must be placed at suitable heights to allow for the bending radius of the cables concerned and making off of cables. Gland plates for single core cables shall be manufactured from insulating material of adequate strength.

3.4 DOORS AND COVERS

3.4.1 Where doors are provided it shall have at least the following number of hinged points:

<table>
<thead>
<tr>
<th>HEIGHT [H]</th>
<th>NO OF HINGED POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \leq 450\text{mm}$</td>
<td>2</td>
</tr>
<tr>
<td>$450\text{mm} &lt; H \leq 800\text{mm}$</td>
<td>3</td>
</tr>
<tr>
<td>$H &gt; 800\text{mm}$</td>
<td>4</td>
</tr>
</tbody>
</table>

3.4.2 All doors shall be fitted with rubber or neoprene seals.

3.4.3 Door and cover latches shall be of robust construction and shall be manufactured from steel. Doors and covers shall be secured by square key latches as follows:

<table>
<thead>
<tr>
<th>HEIGHT [H]</th>
<th>NO OF LATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \leq 450\text{mm}$</td>
<td>2</td>
</tr>
<tr>
<td>$450\text{mm} &lt; H \leq 800\text{mm}$</td>
<td>3</td>
</tr>
<tr>
<td>$H &gt; 800\text{mm}$</td>
<td>4</td>
</tr>
</tbody>
</table>

3.4.4 Doors and covers greater than 800mm shall be provided with stiffeners / webs to avoid wobbling.

3.4.5 All doors with electrical equipment mounted on it shall be bonded to the protective earth conductor by means of at least a 4mm² multi strand conductor.

3.5 GREE OF PROTECTION

3.5.1 All distribution boards shall be moisture proof, vermin proof and adequately ventilated. Distribution boards shall at all times be protected against damage, moisture, dust and vermin. If IP rating is not specified on the single line drawings or the detail specification the following minimum ratings shall be applicable and shall be tested in accordance with SANS 60529:

3.5.1.1 Indoor use IP3X
3.5.1.2 Outdoor use IP54
3.5.1.3 Cable entry IP2X

3.6 FORM OF SEPARATION

3.6.1 The form of separation shall be as specified on the single line diagrams issued with the specification.

3.7 DEGREE OF POLLUTION

3.7.1 Unless otherwise specified the assembly shall be rated for a degree of pollution of 3.

3.8 LABELLING

3.8.1 All labels shall be of engraved Trafolite or similar plastic material and shall be fixed by means of machine screws or aluminium channelling.

3.8.2 Lettering shall be black on white background. Glued-on plates or embossed plastic self-adhesive tape labels shall not be accepted.

3.8.3 The distribution board ID as well as where the panel is supplied from will be secured to the panel.

3.8.4 All circuit breakers, contactors, timers, switches, relays, pushbuttons, terminals, etc., must be clearly labelled as to their title or function.

3.8.5 All wire ends to contactors, relays, terminal strips, etc., must be clearly numbered by means of slip-on plastic ferrules. Self-adhesive tape markers shall not be acceptable.

3.8.6 All terminal strips must be numbered on both incoming and outgoing sides by means of suitable clip-on numbers. Should the incoming and outgoing wire numbers be identical, then numbers on one side only of a terminal strip shall be acceptable.

3.8.7 A suitable legend card (paper shall not be acceptable) covered by a removable glass or perspex panel shall be provided and installed inside the door or on the face of the panel. This legend card shall give the designation of the various outgoing circuits, the corresponding circuit breaker numbers in the board and the area where the circuit is taken to. i.e. lights, L1, Kitchen.

3.8.8 During construction temporary hand written legend cards shall be used. Final legend cards must be typed. Hand written final legend cards shall not be accepted.

3.8.9 The following information shall appear on the name plate which shall be secured to the assembly’s incomer section:

3.8.9.1 Assembly ID
3.8.9.2 Manufacturer’s trade name, address and contact number
3.8.9.3 Standard to which the panel has been manufactured and tested
3.8.9.4 Main busbar current rating
3.8.9.5 Rated short time withstand current
3.8.9.6 Rated operating voltage
3.8.9.7 Rated insulation voltage
3.8.9.8 IP rating
3.8.9.9 Form of separation
3.8.9.10 Degree of pollution

3.8.10 Where series connected (cascaded) systems are used the warning label shall be fitted on the incomer section of the assembly as noted in the SANS10142-1 regulations.

3.7 BUSBARS
3.7.1 The busbar system shall be manufactured of high conductivity copper complying with SANS804.

3.7.2 Joints in the busbars shall overlap not less than 6 times the thickness of the busbar or shall equal the width of the busbar whichever is the greater. A minimum of two bolts with conical or spring washers shall be used to secure the joint.

3.7.3 The support system shall be designed to cater for the rating of the short time withstand rating of the assembly.

3.7.4 Busbars shall be identified to confirm to which phase it is connected to using Red, White, Blue and Black for Neutral.

3.7.5 In a multi phase assembly the neutral bar size shall not be less than 50% of the phase conductor.

3.7.6 All busbar connections shall be torqued and marked to the standard torque settings.

3.8 EARTHBAR

3.8.1 Each board shall be equipped with a copper earth bar over the full length of the board to allow for the termination of all the incoming and outgoing earth conductors. The protective earth conductor shall be colour coded Green with a Yellow Stripe or left bare.

3.9 WIRING

3.9.1 All internal wiring shall either be laced or run in wiring channels and shall be clearly marked with numbered ferrules and colour coded.

3.9.2 Only one neutral and one earth wire will be allowed per terminal.

3.9.3 The minimum wiring which may be used in the fault free zone is 16mm², and shall be braced at least every 300mm.

4. OUTDOOR KIOSKS

4.1 Outdoor metering or distribution kiosks shall comply with NRS056

4.2 The outdoor kiosks shall be manufactured from 2.0 mm cold rolled sheet steel minimum and shall be of a robust, weather and tamper-proof construction with smooth outer surfaces free of bolt heads, screws, etc. and shall be mounted on a heavy channel iron base. The kiosks shall be designed and constructed to be completely vermin proof and shall be divided into compartments as called for in the "Schedules".

4.3 An inner angle iron frame shall be fitted for the fixing of the equipment chassis and gland plates. The chassis shall be of rigid construction suitable for the mounting of all equipment specified and must be provided with all the necessary means for the secure fixing of all circuit breakers, isolators, meters, etc.

4.4 All chassis shall be adequately protected against corrosion either by galvanising or painting in an approved manner.

4.5 Face panels shall be manufactured from 2.0mm sheet steel, suitably folded to ensure adequate panel rigidity.

4.6 Face and circuit breaker toggles to protrude.

4.7 Meters and single phase circuit breakers shall be flush-mounted behind a removable sheet steel face panel suitably punched to allow only the meter.

4.8 Doors shall be manufactured from 2.0mm sheet steel minimum and shall be of robust construction, suitably folded and braced to ensure adequate stiffness, and the metal surface shall be free from dents and ripples.

4.9 Each compartment shall be provided with a hinged, tamper-proof, weather tight door, complete with robust padlockable turn-catch.
4.10 Effective dust seals must be provided around the edges of doors to ensure that boards are dust and weatherproof.

4.11 The hinges and locking devices shall be of tamper-proof construction and shall be of a corrosion-resistant material.

4.12 Ventilation slots or louvers, each fitted with a non-rusting wire screen shall be provided. These vents shall be so designed as to prevent the ingress of rain, bugs and vermin but will allow adequate ventilation to prevent condensation from forming inside the kiosk.

4.13 On each door a cast aluminium scull and crossbone danger sign in white letters on a red background must be provided and permanently fixed.

4.14 The kiosks shall be suitable for bolting down on concrete plinths. A fully dimensioned drawing of the kiosk with details of the base must be made available to allow suitable plinths to be constructed.

5. TYPE TESTED ASSEMBLIES (TTA) AND PARTIALLY TYPE TESTED ASSEMBLIES (PTTA)

The standard to which the assembly needs to comply will be specified in the detail specification.

5.1 OPTION A – SANS 60439

Where type tested assemblies are required complying to SANS 60439 the manufacturer shall provide a valid type test certificate containing all eight type tests, i.e.:

5.1.1 Temperature rise limits
5.1.2 Dielectric properties
5.1.3 Short-circuit withstand strength
5.1.4 Effectiveness of protective circuit
5.1.5 Short-circuit withstand strength of a protective circuit
5.1.6 Clearances and creepage distances
5.1.7 Mechanical operation
5.1.8 Degree of protection

Any deviation from the type tested design must be substantiated by the rules of the Engineering Design System (EDS)

5.2 OPTION B – SANS 61439

Where type tested assemblies are required complying to SANS 61439 the manufacturer shall provide a valid type test certificate containing all eight type tests, i.e.:

5.2.1 Strength of material and parts
5.2.2 Temperature rise limits
5.2.3 Dielectric properties
5.2.4 Short-circuit withstand strength
5.2.5 Protection against electric shock and integrity of protective circuit
5.2.6 Incorporation of switching devices and components
5.2.7 Internal electrical circuits and connections
5.2.8 Terminals for external conductors
5.2.9 Clearances and creepage distances
5.2.10 Mechanical operation
5.2.11 Degree of protection

A verification report shall be submitted with the submission of the drawings to the engineer containing all the data used, calculations made and comparisons undertaken.
6. MINIMALLY TESTED ASSEMBLIES

6.1 Minimally tested assemblies shall only be accepted where specified in the detail specification. Where this is acceptable the assembly shall comply with SANS 1973-8.

7. FACTORY ACCEPTANCE TESTS

7.1 Prior to the assembly leaving the factory, the manufacturer / contractor shall notify the client that the assembly is ready for a factory acceptance test at least one week prior to the required FAT date.

7.2 Any assembly delivered to site without the client / consultant signing a factory release document after the FAT shall be rejected.

7.3 During the FAT the client / consulting engineer will witness the following:

7.3.1 Verifying that the assembly is manufactured as per the approved drawings, including confirmation that the ratings of the switchgear and control installed.

7.3.2 Inspect the finish of the panel and verifying the paint thickness, should the paint thickness not comply the panel will be rejected.

7.3.3 Visually verify the first digit of the IP rating using a probe

7.3.4 Inspect the wiring in the panel for compliance and neatness

7.3.5 Inspection and verifying the labelling

7.3.6 Verify clearances between phases and phase to earth

7.3.7 Verifying that all doors / covers fit properly

7.3.8 Witness the insulation resistance test

7.3.9 Witness the dielectric test

7.3.10 Witness the functionality of the control circuits

7.4 After the FAT the manufacturer / contractor shall issue a routine test certificate.
1. **GENERAL**

1.1 This standard specification cover the requirements for the switchgear and control gear to be used in LV assemblies.

1.2 The contractor / panel manufacturer shall supply with the GA drawings of the LV assemblies the data sheets of the switchgear and control gear that will be used within the assembly complete with the type testing certificates thereof.

2. **STANDARDS**

The equipment shall comply with the following standards:

A. SANS 10142-1
B. SANS 60947-1
C. SANS 60947-2
D. SANS 60947-3
E. SANS 60947-4
F. SANS 156
G. SANS 556-1
H. SANS 61649-1
I. SANS 947-4-1

3. **DESCRIPTION**

3.1 **AIR CIRCUIT BREAKERS (ACBS)**

3.1.1 ACBs shall be of the fully type tested in accordance with the requirements of SANS 60947-2 and shall be of withdrawable type and shall have switch-disconnector characteristics.

3.1.2 ACBs shall have the following characteristics:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (Iₙ)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Operating Voltage (Uₑ)</td>
<td>≥600V</td>
</tr>
<tr>
<td>Rated Insulation Voltage (Uᵢ)</td>
<td>≥800V</td>
</tr>
<tr>
<td>Rate Ultimate Short-circuit rating (Iₘₜₚ)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Service Short-circuit Rating (Iₘₚ)</td>
<td>100% of Iₘₜₚ</td>
</tr>
<tr>
<td>Rate Short-circuit Making capacity (Iₘₘₚ)</td>
<td>As per SANS 60947-2</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.1.3 ACBs shall have the following properties:

3.1.3.1 Quick make/break type spring assisted operating mechanism.

3.1.3.2 Trip free mechanical manual closing mechanism.

3.1.3.3 Manual operated mechanical trip mechanism suitably protected to prevent inadvertent tripping.

3.1.3.4 Positively driven mechanical device to provide on/off/trip indication. This indication shall be clearly visible with the circuit breaker in position.

3.1.3.5 Auxiliary contacts, if specified, shall be electrically separated.

3.1.3.6 The fixed cradle shall be of a high mechanical strength.

3.1.3.7 Clearly marked position indications as racked-out, test and engaged.

3.1.3.8 It shall not be possible to insert an ACB unto a circuit of lower or higher rating than its rating.
3.1.3.9 Automatic-operated shutters shall be provided so that on disconnecting the circuit breaker, these shutters cover the isolating to prevent inadvertent contact with live busbars and conductors.

3.1.3.10 Shutters shall be capable of being padlocked in the closed position.

3.1.3.11 The circuit breakers shall be provided with facilities to padlocked in the isolated position

3.1.3.12 It shall not be possible to withdraw or insert of the unit when the circuit breaker is in the closed position.

3.2 MOULDED CASE CIRCUIT BREAKERS (MCCBS)

3.2.1 MCCBs shall comply with VC 8036, SANS 556-1 and SANS 60947-2

3.2.2 MCCBs can be either fixed or withdrawable type, but shall be as specified on the single line diagrams.

Note: Adjustable thermal magnetic tripping units will be accepted for operating current of up to and including 250A, circuit breakers with higher rated current shall be supplied with adjustable electronic tripping units.

3.2.3 MCCBs shall have the following characteristics:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (In)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Operating Voltage (Ue)</td>
<td>≥230V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥400V form multi pole</td>
</tr>
<tr>
<td>Rated Insulation Voltage (Ui)</td>
<td>≥250V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥500V form multi pole</td>
</tr>
<tr>
<td>Rate Ultimate Short-circuit rating (Icu)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Service Short-circuit Rating (Ics)</td>
<td>100% of Icu</td>
</tr>
<tr>
<td>Rate Short-circuit Making capacity (Icm)</td>
<td>As per SANS 60947-2</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.2.4 All MCCBs shall be equipped with adjustable inverse time delay over-current release with instantaneous tripping under short-circuit conditions in accordance with SANS 60947-2.

3.2.5 Where fixed type MCCBs are used the toggle shall protrude through the internal assembly cover. The MCCBs shall be supplied with a pad lockable device which shall be integral to the MCCBs, to enable locking the operating lever in the open (off) position.

3.2.6 Where withdrawable units are used the following shall apply:

3.2.6.1 The fixed cradle shall be of a high mechanical strength.

3.2.6.2 Clearly marked position indications as racked-out, test and engaged.

3.2.6.3 It shall not be possible to insert an MCCB unto a circuit of lower or higher rating than its rating.

3.2.6.4 Automatic-operated shutters shall be provided so that on disconnecting the circuit breaker, these shutters cover the isolating to prevent inadvertent contact with live busbars and conductors.

3.2.6.5 Shutters shall be capable of being padlocked in the closed position.

3.2.6.6 The circuit breakers shall be provided with facilities to padlocked in the isolated position

3.2.6.7 It shall not be possible to withdraw or insert of the unit when the circuit breaker is in the closed position.
3.3 MINIATURE CIRCUIT BREAKERS (MCBS)
3.3.1 MCBs shall comply with VC 8036, SANS 556-1 and SANS 60947-2
3.3.2 MCBs shall have the following characteristics:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (In)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Number of poles</td>
<td>As specified on single line diagrams</td>
</tr>
<tr>
<td>Rate Operating Voltage (Ue)</td>
<td>≥230V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥400V form multi pole</td>
</tr>
<tr>
<td>Rated Insulation Voltage (Ui)</td>
<td>≥250V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥500V form multi pole</td>
</tr>
<tr>
<td>Rate Ultimate Short-circuit rating (Icu)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Short-circuit Making capacity (Icm)</td>
<td>As per SANS 60947-2</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.4 EARTH LEAKAGE DEVICES
3.4.1 Earth leakage units shall comply with the following VC8035, SANS 60947-2, SANS 61008-1 & SANS 767-1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (In)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rated leakage current (IΔn)</td>
<td>30mA unless otherwise specified</td>
</tr>
<tr>
<td>Number of poles</td>
<td>As specified on single line diagrams</td>
</tr>
<tr>
<td>Rate Operating Voltage (Ue)</td>
<td>≥230V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥400V form multi pole</td>
</tr>
<tr>
<td>Rated Insulation Voltage (Ui)</td>
<td>≥250V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥500V form multi pole</td>
</tr>
<tr>
<td>Rate Ultimate Short-circuit rating (Icu)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rate Short-circuit Making capacity (Icm)</td>
<td>As per SANS 60947-2</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.4.2 The relays shall operate on the core balance principle to energise the trip coil of the associated circuit breaker by means of a static switching device or magnetic amplifier of simple design.

3.5 SWITCH DISCONNECTORS
3.5.1 The switch disconnectors shall comply with SANS 60947-3

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current (In)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Number of poles</td>
<td>As specified on single line diagrams</td>
</tr>
<tr>
<td>Rate Operating Voltage (Ue)</td>
<td>≥230V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥400V form multi pole</td>
</tr>
<tr>
<td>Rated Insulation Voltage (Ui)</td>
<td>≥250V Single pole</td>
</tr>
<tr>
<td></td>
<td>≥500V form multi pole</td>
</tr>
<tr>
<td>Rate Short-circuit withstand rating (Icw)</td>
<td>As specified on single line diagram</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50Hz</td>
</tr>
</tbody>
</table>

3.5.2 Depending on the requirements as set out in the detail specification and single line diagrams the switch disconnectors shall have the same qualities as the circuit breakers with the same rated current and rated short circuit current.
3.6 SURGE PROTECTION DEVICES

3.6.1 Unless otherwise specified the minimum requirements as set out in the SANS 10142-1, shall be adhered to.

3.6.2 All surge protection devices for low voltage systems shall comply with SANS 61643-1 & 61643-12 and proof of compliance shall be submitted with the tender.

3.6.3 All main distribution boards were specified shall be provided with a protection against surge voltages on all three phases and the neutral conductor.

3.6.4 The lightning arrestors shall consist of a parallel circuit of metal oxide varistors and lightning current absorbing surface discharge arrestors (e.g. spark gap), which automatically quench the follow current.

3.6.4 Where Class 1 type surge protection devices are specified, the value of the impulse current ($I_{\text{imp}}$) for SPD’s connected between phase and neutral shall not be less than 12.5kA for the 10/350μs wave form and for SPD’s connected between Neutral and PE shall not be less than 25kA for single phase and 50kA for three phase systems 5kA for the 10/350μs wave form.

3.6.5 Where Class 2 type surge protection devices are specified, the value of the nominal discharge current for SPD’s connected between phase and neutral shall not be less than 5kA for the 8/20μs wave form and for SPD’s connected between Neutral and PE shall not be less than 10kA for single phase and 20kA for three phase systems for the 8/20μs wave form.

3.6.6 All Class 2 type surge protection devices shall visually indicate the end of life of the device and shall consist of two parts, a base and a plug-in protection module.

3.6.7 All elements of the surge protection installation shall be of one manufacturer.

3.6.8 The units shall be installed strictly in accordance with the manufacturer’s instructions e.g., position, protection, wire sizes and lengths, etc.

3.7 CONTACTORS

3.7.1 All contactors shall comply with SANS 60947-4-1.

3.7.2 Contactors shall be of the electromagnetic, air-break type and shall be arranged to interrupt all poles of the supply simultaneously. The number of poles shall be as specified on the single line diagrams.

3.7.3 All contactors used in supply circuits to fluorescent and gas discharge luminaires, electric motors, etc., shall be of the AC3 utilisation category. For resistive loads, contactors with AC1 utilisation category can be used, unless otherwise specified.

3.7.4 Type 2 co-ordination shall be used for the selection of contactors.

3.7.5 The contactor rating shall be in accordance with the specified value of the circuit in accordance with SANS 60947-4-1 and with an utilisation category of AC 3.

3.7.6 The contactor shall withstand the maximum fault level current of the circuit.

3.7.7 Noisy contactors shall not be acceptable.

3.7.8 Contactors with permanently installed auxiliary contacts shall be provided with an additional 1 x N/O and 1 x N/C contact above the numbers specified for control purposes and services.
3.7.9 The operating voltage of the coil of the contactor shall be as specified on the single line diagrams, and shall be continuously rated.

3.7.10 All contactors shall be of a standard product of a single manufacturer, unless otherwise specified.

3.8 MOTOR STARTERS

3.8.1 All motor starters shall comply with SANS 60947-4-1.

3.8.2 Motor starters can be the conventional circuit breaker, contactor & overload configuration or manual motor starter with integrated overload and contactor configuration.

3.8.3 Motor starters shall have all the remote controls and indicators as specified or indicated on the single line diagrams, but as a minimum it shall have the following:

   3.8.3.1 Phase failure protection
   3.8.3.2 Auto/Off/Manual selector switch (unless otherwise specified) with auxiliary contacts for remote monitoring
   3.8.3.3 On Auto selection it shall have a remote start contact
   3.8.3.4 On the Manual it shall active the contactor directly
   3.8.3.5 Overload indication (Red LED indicator lamp)
   3.8.3.6 Motor running (Green LED indicator lamp)
   3.8.3.7 Contacts for remote status monitoring

3.8.4 Type 2 coordination shall be used for selection of equipment.

3.8.5 Adjustable thermal overload release and instantaneous trip units shall be supplied on the overload devices, and the overload devices shall not operate under starting conditions.

4. INSTRUMENTATION, METERING AND CONTROL

4.1 TIMERS

4.1.1 Time switches shall be of the single pole type and suitable for 230V installations. The contact rating shall be suitable for the specified service, but shall be 15 Amp minimum. Contacts shall be manufactured of high quality material, such as silver plated or solid silver.

4.1.2 The time piece shall be driven by a selfstarting synchrone hysteresis motor and shall be provided with a minimum spring reserve of 72 hours and shall be wound up electrically. The main spring shall be kept fully wound up, but a slip clutch shall not be used and shall be completely reloaded within 15 minutes after power is restored.

4.1.3 The time switch shall be provided with weekend switching.

4.1.4 The switch shall be provided with a moulded plastic or metal casing with a plastic face plate and moulded plastic or metal base for Din rail mounting, or to clip-in on circuit breaker rail.

4.1.5 The time switch shall be provided with a manual operated by-pass switch.

4.2 PUSH BUTTONS AND APPARATUS
4.2.1 Push buttons and apparatus shall be provided from the standard range of one manufacturer. All push buttons shall have the same physical dimensions and shall be as far as possible inter-changeable with indicator lamps, key switches, etc.

4.2.2 The push buttons shall be designed for a long service life and the movement shall be of the mechanical type with spring loaded contacts and coupling or catch type.

4.2.3 All pushbuttons shall have replaceable lenses suitable for a variety of symbols. Name plates shall be of the inter-changeable type.

4.2.4 All terminals shall be suitable for the conductor sizes as used. Exposed push buttons shall be of the complete enclosed type. For low voltage and currents contacts with wiping action shall be used, and of the catch contact type for higher currents and voltages.

4.2.5 Illuminated push buttons shall be provided with LED lamps. Lamp voltages shall adapt the control voltage, but the control voltage shall be of a lower value as the lamp voltage. Push buttons shall be in accordance with the applicable requirements of SANS 60947-5-1.

4.2.6 The following colours shall be used for the push buttons:

4.2.6.1 Red - Stop or emergency stop
4.2.6.2 Green - Start (preparation/working)
4.2.6.3 Yellow - Disrupt a function (action)
4.2.6.4 White - Any function not covered in the above

Other applicable colours for special functions shall have to be approved by the engineer.

4.3 INDICATOR LIGHTS

4.3.1 The indicator lights shall be of the incandescent, neon or LED type lamps. The lamp voltages shall adapt the control voltage, but the control voltage shall be of a lower value as the lamp voltage.

4.3.2 The indicator lights shall be in accordance with SANS 60947-5-1 where applicable.

4.3.3 Indicator lights shall be suitable for mounting in distribution board panels and doors and shall consist of a mounting pedestal with lamp holder, an interchangeable lens, terminals and facilities for the installation.

4.3.4 Lamps shall be replaceable from the front of the panels without the use of any tools. All indicator lights shall be of the same standard range of one manufacturer, and shall have the same physical dimensions and be interchangeable with key switches and push buttons.

4.3.5 The following colours shall be used for indicator lights.

4.3.5.1 Red - Abnormal condition (alarm)
4.3.5.2 Yellow or Orange - Attention (careful)
4.3.5.3 Green - Safe (In action)
4.3.5.4 White or Clear - Circuit alive (or normal)
4.3.5.5 Blue - Any other function not covered in the above.

Other applicable colours for special function have to be approved by the engineer.

4.4 METERS
4.4.1 Analogue Voltmeters

Voltmeters shall be of the moving iron flush mounting type, with Class 1.5 accuracy as specified in IEC 60051-1 locally manufactured with 96 mm square flush panel mounting and fitted with unbreakable macrolon glass fronts. The voltmeters shall be suitable for operation on a 50 Hertz system. The voltmeters shall be manufactured in accordance with BS 89 to industrial grade accuracy as specified therein.

The voltmeters shall be protected by high rupturing capacity cartridge fuses to SANS 60269-1 & 2 housed in suitable insulated fuse carriers with a panel-mounting base. Voltmeter selector switches shall be provided and shall have an off- and 8 metering positions, between the phases and between each phase and neutral.

4.4.2 Analogue Ammeters

The ammeters shall comply with IEC 60051-1.

The instruments shall be flush panel mounting, locally manufactured with 96 mm square face match the voltmeters and fitted with unbreakable macrolon glass fronts.

The ammeter shall be of a moving iron type showing the instantaneous current value, combined with a maximum ammeter employing a bimetallic spiral device which will indicate the mean current value over a 15 minute period, fitted with a residual pointer to indicate the maximum mean current reached during any period between manual resetting.

The bimetallic system shall incorporate ambient temperature compensation.

4.4.3 Voltmeter Selector Switches

Unless otherwise specified each distribution board shall be provided with one voltmeter and selector switch.

The voltmeter selector switch shall have an "OFF" position and six measuring positions for all phase/neutral and phase to phase readings.

The switch shall be of the rotary type with CAM or WHIPE action air break contacts with two openings per pole.

The positions shall be clearly and accurately indicated on the faceplate in relation to the handle position.

The selector shall be suitable for flush mounting.

4.4.4 Voltmeter Fuses

The voltmeter fuses shall be of the cartridge type with fuse carrier and fuse base with terminals. The fuse shall only be removable after drawing out of the fuse carrier and to remove the cartridge from the carrier. Rewireable fuses shall not be acceptable. The fuse holder base shall be designed and manufactured for flush mounting and shall be installed on the same panel with selector switch and the voltmeter.

4.4.5 Current Transformers

Current transformers shall be of the ring type and shall be neatly installed. The area for the conductor shall be just big enough for installation to prevent inaccuracy. The current transformers shall be designed for the specified primary current with a 5 Amp secondary current.

The current transformer rating shall be designed to take the instrument load to prevent any misreading.

For indicating instruments the accuracy shall be Class 5. For measuring purposes the accuracy up to 200A shall be
Class 1, from 250 to 600 A Class 0.5 and from 800A up shall be Class 0.2. Safety Class shall be 5 P or 10 P as applicable.

All current transformers shall be provided with labels with non-removable lettering, indicating:

4.4.5.1 Manufacturer
4.4.5.2 Series number and type
4.4.5.3 Primary and secondary currents
4.4.5.4 Frequency
4.4.5.5 Rating and accuracy class
4.4.5.6 Highest Installation voltage
4.4.5.7 Insulation provision

The current transformers shall be designed to accept the dynamic powers of the specified fault level.

4.5.6 Energy Meters

Energy meters shall comply with SANS1799, SANS62053-11

The meters shall have the following minimum requirements:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MINIMUM REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage measurements input for direct connections</td>
<td>120 to 480V</td>
</tr>
<tr>
<td>Current for direct connections</td>
<td>5 to 50A</td>
</tr>
<tr>
<td>Current though current transformers</td>
<td>1, 2 &amp; 5A</td>
</tr>
<tr>
<td>Measurement frequencies</td>
<td>50Hz ±10%</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>Class 1</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-25°C to 55°C</td>
</tr>
</tbody>
</table>
| Output                                           | • Instantaneous values for: Current, Voltage, Power Factor, Frequency
|                                                  | • Active, reactive and apparent energy                    |
| Memory                                           | Meters shall have on board memory to provide demand log, daily, weekly and monthly usage log (only if specified) |
| Communication                                    | Modbus via RS485                                         |
1. TYPES OF CONDUIT

1.1 SCREWED METAL CONDUITS

1.1.1 Screwed steel conduits shall be of the welded or solid drawn heavy gauge tubing, in accordance with SANS 1065-1 and SANS 1065-2 and shall bear the SABS mark. The finish shall be black enamel or hot dip galvanised in accordance with SANS EN 10240.

1.2 OTHER METAL CONDUIT SYSTEMS

1.2.1 Alternatively, other steel conduit systems may be used where the local authority permits. The conduit shall be of minimum 0.9 mm thickness and shall comply with SANS 1065-1 and SANS 1065-2.

1.2.2 The finish shall be black enamel or hot dip galvanised in accordance with SANS EN 10240.

1.2.3 These types of conduits and accessories shall not be used for the suspension of loads such as light fittings. These types of conduit installations shall not be used for flameproof installations.

1.2.4 Screwless metallic conduit shall not be used without the Engineers approval. The whole system shall be the product of one manufacturer.

1.3 NON METALLIC CONDUIT

1.3.1 Non metallic conduit shall not be used unless approved by the Local Authority and approved in writing by the Engineer. Non metallic conduit shall comply with SANS 950 and installation shall comply with Appendix C of SANS 950 and with the requirements of the Local Authority.

1.3.2 Light fittings etc., shall not be supported from non metallic conduit or boxes but shall be fixed to the surrounding structure.

1.3.3 Plastic conduit shall be rigid, heavy gauge PVC, bearing the SABS mark. During construction precaution shall be taken to prevent mechanical damage to plastic conduit.

1.3.4 Where plastic boxes are used as outlets for light fittings, the special devices provided by the manufacturer to eliminate heat conductance to the box shall be provided.

1.3.5 Plastic conduit shall be assembled with the solvent adhesive supplied by the manufacturer. The manufacturers instructions must be closely followed.

1.4 FLEXIBLE CONDUIT

1.4.1 Flexible conduit shall comply with SABS IEC 60614–2-5 and shall be used in accordance with Clause 6.5.4 of SANS 10142-1. Flexible conduit shall comprise galvanised metallic conduit. PVC sheathed galvanised metal conduit or metal reinforced PVC conduit (Anaconda Sealtite), shall be used in damp or humid areas.

1.4.2 Flexible conduit shall be used for connection to moveable equipment to enable adjustment during normal operation and for the connection of motors, any other vibrating equipment, connection of thermostats, sensors on equipment and for stove and geyser connections.

1.4.3 Flexible conduit shall be connected to the remainder of the installation by means of a draw box.
1.5 **GALVANISED CONDUIT SHALL BE USED:**
   a) Where installed in positions exposed to the weather or in moist surroundings.
   b) For installations within 30 km of the coast.
   c) Where required by the Local Authority.
   d) Where the conduit is in contact with the soil.
   e) At ends intended for future extension.

1.6 **MINIMUM CONDUIT SIZE**

1.6.1 All conduits shall have a minimum of 20 mm diameter.

1.7 **BOLTS, SCREWS AND NUTS**

1.7.1 Only steel lock nuts of thick gauge with milled sides shall be used. Cadmium plated bolts and nuts shall be used. Where installation is exposed to the weather brass bolts and nuts shall be used.

1.8 **CONDUIT TERMINATIONS**

1.8.1 Conduits shall be terminated by means of a brass bush and two lock nuts. The conduit end shall only project far enough through the hole to accommodate the bush and lock nut.

1.9 **JOINTS**

1.9.1 Only approved couplings shall be used. All conduit ends shall be reamed and all joints tightly screwed, locknuts shall be provided to ensure a mechanically strong joint and electrical continuity.

1.9.2 All joints shall be treated again to prevent them from rusting in damp areas, coastal areas and where the installation is exposed to the weather for any length of time.

1.10 **CONTINUITY**

1.10.1 Earth continuity shall be maintained throughout the complete installation.

2 **INSTALLATION OF CONDUITS (GENERAL)**

2.1 **POSITIONING OF OUTLETS**

2.1.1 All outlets, etc. shall be accurately positioned. It is the Contractor’s responsibility to ensure that all accessories are installed level, square at the correct height and depth behind plaster. The maximum depth from wall surface to the outlet box shall be 15 mm.

2.2 **DRAW WIRES**

2.2.1 Galvanised steel draw wires shall be installed in all unwired conduits, e.g. spare conduits, telephone, intercom or other installation services.

2.3 **BENDS AND DRAW BOXES**

2.3.1 Pre-fabricated bends or elbows will not be allowed except where specially approved. All bends shall have a radius of at least five times the outside diameter of the conduit. Conduit showing signs of flattening or cracking shall be rejected.

2.3.2 Draw boxes shall be installed at maximum 15 m intervals for straight conduit runs in approved positions so that not more
than two bends occur between one end of a run and draw box or between boxes. Draw boxes shall be arranged so as to be accessible after the completion of the building and must be provided with cover plates, which shall finish neatly and flush in the final surface, except where the surfaces are finished in panelling, in which case a door to match the panelling shall be provided at the expense of the Electrical Contractor.

2.3.3 Inspection elbows, solid bends and tees shall not be used.

2.3.4 Draw boxes shall, where possible, be located in inconspicuous places allowing for a common cover, and rectangular boxes shall be square with respect to walls.

2.3.5 Positions of all draw boxes shall be indicated on the "As Built" drawings.

2.4 REAMING

2.4.1 All conduit ends shall be cleaned internally by means of a reamer of all burrs and rough edges in compliance with the Wiring Code.

2.5 WALL BOXES

2.5.1 Wall boxes for socket outlets, isolators, switches, etc., shall be of the heavy gauge pressed steel galvanised type, provided with substantial lugs, and shall be drilled and tapped for fixing screws.

2.5.2 Knockout conduit entry holes shall be provided at the back and the sides.

2.5.3 Fittings shall be provided with gaskets or machined watertight covers when used externally or in damp situations.

2.5.4 Deep boxes shall be used for cast-in conduit work where these are required by structural considerations. Wall boxes shall be installed at a maximum depth of 15 mm behind wall surfaces.

2.5.5 Where accessories are fixed directly to tapped holes in conduit boxes, the boxes shall be fixed independently of the conduit system.

3. INSTALLATION IN CEILING VOIDS

3.1 Conduits fixed in voids over suspended ceilings shall be rigidly supported from the structural ceiling.

3.2 Conduits fixed in roof voids shall be fixed square with structural beams or parallel.

3.3 Conduit shall not be installed within 150 mm of hot or chilled water pipes and shall run below the former.

3.4 All draw boxes and outlet boxes for future equipment shall be covered with suitable standard blank covers or as specified.

4 INSTALLATION IN CONCRETE

4.1 The Contractor shall ensure that all conduits and accessories, which are to be cast into concrete are placed in their correct positions in good time to avoid any delays to the builders programme. Once the installation has been completed, the Contractor shall advise the Engineer in order that the installation may be inspected by the Engineer before the concrete is to be cast. The Electrical Contractor or his representative shall be present when the concrete is cast to ensure that no damage or displacement to conduit occurs.

4.2 Parallel running conduits shall be sufficiently spaced so that the structural strength of beams slabs etc., is not affected.

4.3 All conduits, outlet boxes, draw boxes etc., shall be securely fixed to the shuttering to prevent displacement when
Where conduits are installed in screeds, the top of the conduit shall be at least 30 mm below the surface of the screed. A minimum distance of twice the outside diameter of the conduit shall be left free between adjoining conduits. Conduits shall be secured to the concrete slab at intervals not exceeding 2.0 metres.

4.5 Where possible, conduits shall not be installed across expansion joints. If this cannot be avoided a conduit expansion joint as approved by the Engineer must be installed. Earth continuity must be maintained through all expansion joints.

4.6 Where a number of conduits are installed in parallel they shall cross the expansion joint of the structure via a single draw box. A number of draw boxes adjacent to each other will not be allowed.

5 INSTALLATION INTO BRICKWORK

5.1 Conduits and outlet boxes etc., to be built in shall be supplied and fixed in the correct position by the Electrical Contractor in accordance with the programme of the builder. As far as possible the chasing in of conduits should be avoided.

5.2 Chases shall be made deep enough to ensure that the conduits are at least 20 mm below the finished plaster surface.

5.3 All chases shall be carried out by means of chasing machines.

5.4 Where the Contractor is responsible for the chasing and building-in of conduits or other equipment, he will be responsible for all damage as a result of this work and will be required to made good at his own cost.

5.5 Under no circumstances shall concrete structures, face brick walls or finished surfaces be chased or cut without the written permission of the Engineer or Architect.

5.6 Where outlets are installed into face brick walls an extension box shall be provided in front of the outlet box. This extension box shall be flush with the face of the wall.
1. **GENERAL**

Wiring channels shall be of “O-Line” or “Electroduct” type or approved equivalent. It shall be manufactured of hot dip galvanised rolled steel.

Wiring cable trays and ladders shall comply with SANS 763 with respect of finishes. PVC trays shall be rigid unplasticised.

The Contractor shall supply and install all wiring channels, cable trays and/or ladders as specified or as required including the necessary supports, clamps, hangers, fixing materials, bends angles, junctions, reducers, T-pieces etc. He shall further liaise with the Main Contractor for the provision of holes and access. All wiring channels, cable trays or ladders shall be properly earthed.

1.1 **SUPPORTS**

1.1.1 Trays and ladders shall be supported at the following maximum intervals:

<table>
<thead>
<tr>
<th>Description</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 mm thick metal trays with 12 mm return</td>
<td>1m</td>
</tr>
<tr>
<td>Metal trays with folded over return and 50 mm upstand</td>
<td>1,22m</td>
</tr>
<tr>
<td>2.4 mm thick metal trays, and 75 mm return</td>
<td>1,5m</td>
</tr>
<tr>
<td>Metal cable ladders</td>
<td>1,5m</td>
</tr>
<tr>
<td>3.0 mm thick PVC trays with 40 mm return</td>
<td>1,0m</td>
</tr>
<tr>
<td>4.0 mm thick PVC trays with 60 mm return</td>
<td>1,5m</td>
</tr>
</tbody>
</table>

1.1.2 In addition trays and ladders shall be supported at each bend, offset and T-Junction. The above spacing of supports is applicable to both vertical and horizontal installation of trays and ladders.

2 **WIRING CHANNELS**

2.1 **JOINTS**

2.1.1 All joints shall be aligned and secured by means of standard connection pieces that are pop-riveted to both adjoining sections. Adjoining sections shall butt tightly. Covers shall fit tightly across the joint. All joints/terminations shall be made electrically continuous.

2.2 **EXPANSION JOINTS**

2.2.1 Where channels cross expansion joints suitable expansion joints shall be provided in the channels by means of fish plates pop-riveted to the channel on one side of the expansion joint and floating freely in the channel on the other side of the expansion joint. Such expansion joints shall be made electrically continuous by installing a coiled conductor of suitable size across the joint.
2.3 SUPPORT FOR CONDUCTORS

2.3.1 All conductors in inverted cable channels shall be retained by means of standard clips or spacer bars at approximately 1m centres.

2.4 FINISHES

2.4.1 Burrs and sharp edges shall be removed and the inside edges of all joints shall be lined with rubber protective lining or other suitable rubberised or plastic compound to prevent laceration of the conductor insulation.

2.4.2 All holes through, which conductors pass shall be fitted with grommets.

2.5 VERMIN PROOFING

2.5.1 All wireways shall be made vermin proof. Holes shall be covered by means of screwed metal plugs or by means of metal strips that are pop-riveted to the channel.

2.6 COVER PLATES

2.6.1 Where possible the suppliers’ standard metal or PVC cover plates shall be used. All cover plates shall be neatly and securely fitted.

2.6.2 Steel cover plate finishes shall be the same as for the channels.

2.7 WIRING CHANNEL CAPACITIES

2.7.1 The overall cross sectional areas of all conductors, including insulation, shall not exceed 45% of the total internal cross sectional area of the trunking whilst in the case of ducting, this figure shall be 40%.

2.8 FIXING OF CHANNELS

2.8.1 The Contractor shall supply and install all hangers, supports or fixings as required for the channels. Channels shall be supported at maximum intervals of 1.5m or as otherwise specified. Channel runs shall be carefully planned to avoid clashes with other services and to ensure that all covers can be removed after completion of the entire installation. Standard clamps, hangers etc. shall be used as required. Where it is not possible to support the channels at the specified intervals, they shall be supported in a sound manner to the satisfaction of the Engineer.

2.9 INSTALLATION IN CONCRETE

2.9.1 Channels shall be filled with suitable fillers to prevent the ingress of cement and shall be securely fixed in position to the shuttering.

2.10 ACCESSORIES

2.10.1 All accessories i.e. hangers, cover brackets, etc. shall be standard items and in general have the same finish as the channels.

2.10.2 Purpose made accessories shall not be acceptable.
3. CABLE TRAYS AND LADDERS

3.1 JOINTS

3.1.1 Joints shall be made smooth without rough edges etc., that may damage the cable. Joints shall as far as possible be arranged to occur at supports. Where joints do not coincide with supports, joints shall be made by means of wrap-around pieces of the same thickness of the tray and at least 200mm long. The two cable tray ends shall butt tightly in the centre of the splice, the splice shall be bolted to each cable tray by means of at least 4 round head bolts, nuts and washers on each side of the joint. Splices with the same finish as the tray shall be provided at joints which do coincide with supports.

3.2 EXPANSION JOINTS

3.2.1 Where cable trays or ladders cross expansion joints, the trays or ladders must form a gap of at least 25 mm between the two sections. Cables installed across expansion joints, must have enough slack to accommodate the expansion of the building.

3.3 EARTHING

3.3.1 Bare copper conductors or straps of sufficient length to accommodate expansion and contraction shall be installed across all expansion joints, also to joints where continuity cannot be guaranteed. These additional conductors shall always be installed in outdoor conditions or coastal regions.

3.4 FIXING

3.4.1 Trays and cable ladders shall be bolted to supports by at least two bolts per support.

3.4.2 It is the responsibility of the Contractor to ensure that adequate fixing is provided and the manufacturer's instructions shall be strictly adhered to. Intervals between brackets above 1.5m shall not be acceptable. Cable trays and ladders that work loose shall be rectified at his own expense.

3.4.3 The fixing shall take into account conditions on site during installation.
1. WIRING

1.1 CONDUCTORS

1.1.1 Except where otherwise specified all wiring shall be carried out with PVC insulated, stranded copper conductors and bare stranded copper earth wires, complying with SANS 1507 and the installation shall comply with SANS 10142-1 as amended.

1.1.2 All wiring shall be installed in conduit, trunking or ducting as specified. Open wiring will not be accepted.

1.1.3 The wiring of any circuit shall only be carried out after the whole of the conduit installation for that particular circuit has been installed and fixed in position. No wires shall be drawn through before the conduit has been thoroughly cleaned of all debris and moisture and that the building work is at a stage that there is no likelihood of the ingress of dirt and moisture.

1.1.4 It should also be possible for wires to be drawn through the completed conduit installation without any undue strain.

1.1.5 Wires drawn into conduits etc., shall be of sufficient length to allow the connection of fittings, appliances, etc.

1.1.6 As a minimum, light circuits shall be wired with 2,5mm² and plug circuits with 4 mm² conductors, except as otherwise specified.

1.1.7 Wiring shall be sized to carry the load of the circuit as shown plus an allowance of 10% for future connections and in accordance with the overall voltage drop requirements of the Wiring Regulations. The same allowance shall be made when determining the wiring capacity of each conduit run. Attention is drawn to the application of grouping factors to the rating of wires in conduit and trunking.

1.1.8 All conductors shall be colour coded to facilitate identification of the circuit and switch wiring, black for neutral conductors only and green for insulated earth conductors. Three phase circuits shall be colour coded to identify phases.

1.1.9 All wiring shall be carried out by means of the loop-in system. Jointing of conductors shall not be permitted.

1.1.10 Where conductors of more than one circuit are installed in wireways, the conductors of each circuit shall be PVC taped together at intervals of one metre. Appropriate circuit grouping factors must be applied to prevent overheating. A common, unbroken suitable sized earth conductor may be installed into the wireways and crimped ferrule connections shall be used for subsidiary earth conductors to the various outlets.

1.1.11 With the exception of three phase outlets, circuits of different phases shall not be drawn into the same switch or outlet boxes.

1.1.12 In order to support the mass of the conductors installed in vertical wireways these conductors shall be secured at intervals not exceeding 5m by means of suitable clamps.

1.1.13 The end strands of all wires, whether single or looped, to be connected to the connection terminals of light fittings or any equipment are to be tightly twisted together. There shall be no cutting away of wire strands.

1.1.14 Protective edge strips shall be provided to avoid damage to conductor insulation when drawn into wiring trunking etc. The Engineer shall reject any conductor with such damage. These conductors shall then be replaced at the contractor’s own expense.
1.2 COPPER BRAIDED CABLE

1.2.1 Except where otherwise specified, all copper braided cable shall consist of PVC insulated copper conductors size and number of cores as specified. The total conductor area of the braiding shall be as specified in SANS 150-1970 clause 11.7.

1.2.2 Both the PVC insulated copper conductors and the copper braiding shall comply with the applicable SABS regulations.

1.2.3 Installation of copper braided cables shall be carried out in accordance with SANS 10142-1 as amended.

1.2.4 In roof spaces and ceiling voids, where the cables are unlikely to be disturbed, the cables need not be secured. However, the cables shall be neatly grouped together, saddled and strapped as far as possible.

1.2.5 All wiring from the roof space etc. to wall mounted outlet boxes shall be installed in a suitably sized conduits.

1.2.6 Where copper braided cable enters powerskirting etc. the cable will be connected to the first outlet on the circuit, the remaining outlets in the powerskirting etc. shall be connected using PVC insulated conductors and copper earth conductor, or as otherwise specified.

1.2.7 It should also be possible for cables to be drawn through the completed conduit installation without any undue strain.

1.2.8 Copper braided cables drawn into conduits etc., shall be of sufficient length to allow the connection of fittings, appliances, etc.

1.2.9 As a minimum, copper braided cable conductor sizes for light circuits shall be 1.5mm² and plug circuits 2.5 mm², except as otherwise specified.

1.2.10 Conductors shall be sized to carry the load of the circuit as shown plus an allowance of 10% for future connections and in accordance with the overall voltage drop requirements of the Wiring Regulations. Attention is drawn to the application of grouping factors to the rating of copper braided cables in trunking, and the size of the circuit breaker feeding the circuit.

1.2.11 All conductors of a copper braided cable shall be colour coded to facilitate identification of the circuit, red for live and black for neutral conductors only and green for insulated earth conductors. Three phase circuits shall be colour coded to identify phases.

1.2.12 All wiring shall be carried out by means of the loop-in system. Jointing of cables shall not be permitted.

1.2.13 Protective edge strips shall be provided at openings and mitre joints to avoid damage to braiding and conductor insulation when drawn into wiring trunking etc. The Engineer shall reject any copper braided cable with such damage. These copper braided cables shall then be replaced at the contractor's own expense.

1.2.14 Properly sized gripper glands to suit the cables shall be used where the braided cable enters terminal boxes, outlet boxes, distribution boards, light fittings etc.
1. GENERAL

1.1 The VSD shall be suitable for controlling the speed of standard three phase 380V - 415V induction motors.

1.2 The VSD is required to operate continuously at full load rating of the driven motor with variations of ±10% of the supply voltage and ±2% of the supply frequency.

1.3 The VSD is required to operate continuously at full load in an ambient temperature of 38°C.

1.4 The VSD is required to operate continuously at full load at the stated altitude for the project. Where a de-rating factor is required by the Manufacturer this is to be applied to the VSD and not to the driven motor.

1.5 The VSD is to be manufactured to quality standards according to ISO 9001.

1.6 Unless stated elsewhere to the contrary it is to be assumed that the VSD is to be installed and operated in a high-tech commercial building with multiple tenants with an assortment of computers and sensitive electronic, radio, television and telecommunication equipment. The VSD is therefore required to operate without interference to this equipment.

2. QUADRATIC TORQUE LOADS

2.1 The VSD unit is to be designed and built specifically for centrifugal fan and pump operation.

2.2 Maximum advantage is to be obtained in terms of energy saving by using an output voltage to frequency ratio allowing only sufficient magnetisation energy at the required motor speed.

2.3 The fans and pumps are expected to operate for extended periods at 50% of rated speeds and a running torque requirement of 25% of the rated value. At this 50% speed reduction the power consumption is to reduce to 12.5% of the rated full load value.

3. OPERATING PARAMETERS

3.1 Operating and setup parameters shall be selected and set by means of a programming keypad and associated display.

3.2 The VSD shall be suitable to respond to speed commands from 0 - 10Vdc and 0 - 20mA control signals and their respective inverted signals.

3.3 The VSD shall provide comprehensive information on the controller and motor condition. The following are minimum requirements:

3.3.1 Reference % of control signal.
3.3.2 Frequency Hz
3.3.3 Current A
3.3.4 Torque %
3.3.5 Power kW
3.3.6 Output voltage V
3.3.7 Motor RPM

3.4 The VSD shall be suitable for catching a rotating motor. Under certain conditions, the fan or pump may be rotating in its opposite direction and the VSD shall be capable of achieving a clean start under these conditions.

4. ELECTRICAL SAFETY

4.1 The VSD is to have all necessary WARNING or CAUTION notices permanently fixed to the VSD and VSD enclosure.

4.2 The VSD shall be suitable for service in mechanical plant rooms where dust, moisture and water is present. A minimum enclosure protection to IP54 rating is required. The VSD is to be mounted in a ventilated area allowing the dissipation of heat energy.
4.3 The VSD shall be suitable for switching on the output side. Motor reactors limiting the rise time of the current are a minimum requirement and are to be integral with the VSD.

4.4 Isolation of the mains supply to the VSD and from the VSD to motor is a requirement to allow for safe maintenance, repair and to prevent motor operation during set up procedures.

4.5 In the event that the VSD is mounted exposed to ambient condition the VSD shall have a minimum enclosure protection to IP54 rating and shall have a weather canopy mounted over VSD to protect it from direct sunlight and rain.

5. **GALVANIC ISOLATION**

5.1 The VSD is to provide isolation between the control and power circuits to ensure dangerous voltages cannot be transmitted to control signals. This isolation shall be integral with the VSD and shall be capable of withstanding a test voltage of 2.5KV for 1 second.

6. **MAINS DISTURBANCE**

6.1 The VSD is to be protected against transients on the main supply caused by short circuit faults, lightning strikes and the switching of power factor correction capacitors.

7. **MAINS SUPPLY**

7.1 The VSD to incorporate all necessary chokes filters capacitors and motor coils to reduce and limit radio frequency interference and harmonics to a level which does not interfere with other equipment on the same power supply.

7.2 The VSD is to incorporate harmonic reactors in the d.c. link circuit as an integral part of the VSD.

8. **SYSTEM PROTECTION**

8.1 The VSD system is to provide protection from:

8.1.1 Over current and overvoltage
8.1.2 under voltage
8.1.3 Overload
8.1.4 Over heating

And to include facilities for:

8.1.6 Current limiting setting
8.1.7 Auto restart following trip or power supply recovery
8.1.8 Soft stall function
8.1.9 Reactivation function following a momentary power interrupt

9. **VSD OVERLOAD PROTECTION**

9.1 The VSD is to be protected on the power outlet against short circuits or earth faults on the motor terminals. The three phases of the supply to be continuously monitored and the system to shut down on a missing phase or thermal overload.

9.2 The VSD shall provide storage of all faults. Last fault memory in the event of power failure is required.

10. **MOTOR OVERLOAD PROTECTION**

10.1 The VSD is to provide electronic thermal overload protection of the motor at all operating speeds. This protection is to allow for the cooling conditions experienced with the speed control. The VSD is to allow for a built in motor thermistor should the motor size be 22kW or more.

10.2 The VSD is to incorporate line reactors as necessary to achieve a power factor of the driven motor of not less than 0.9 at
any given speed.

11. **INVERTER WAVEFORM**

11.1 The VSD is to have manufacturers installed protection devices on the outgoing supply to the motor to suppress the effects of the inverter wave form.

11.2 The VSD shall be of the type utilising digital PWM technology which will enable the full output voltage to be reached without waveform distortion. Derating of the specified motor KW is not permitted.

11.3 The VSD is to provide slip regulation by means of vector control of the output voltage and frequency to maintain a constant motor speed.

12. **RADIO FREQUENCY/INTERFERENCE/RADIATED AND CONDUCTED INTERFERENCE**

12.1 The VSD is to have manufacturers built in filters to suppress RFI, radiated and conducted interference.

12.2 The VSD shall comply with EMC/EMI standards for immunity IEC 802-805.

12.3 The VSD is to be contained in a metal enclosure to suppress radiated RFI. The earthing of this enclosure to be taken direct to earth.

13. **MOTOR NOISE**

13.1 Electromagnetic noise generated by the VSD and motor is not to exceed a 10% increase over that of a standard motor on a commercial power supply when operating over the specified duty range.

13.2 The additional vibration generated by the motor when operated at reduced speed shall be attenuated by stiffness of base and selection of anti-vibration mountings. The resultant vibration transmitted to building structure must be no more than that of a standard motor on a commercial power supply.

14. **COMPUTER INTERFACE**

14.1 The VSD will normally be connected to a local standalone controller and with facilities to interface with a BMS system. Interface facilities are required to allow operation and make data settings from a host computer. Monitoring of the speed controller status is to be provided giving:
14.1.1 Output frequency
14.1.2 Output current
14.1.3 Output voltage
14.1.4 Trip conditions

14.2 Where the BMS system is not currently in operation the system is to allow for future connection.

15. **COMMISSIONING**

15.1 The VSD is to be set up and commissioned by the manufacturer. A commissioning report showing all parameters and settings is to be included in the commissioning manual.
1. The safety and control equipment for all subsystems as shown on the Safeties, Instrumentation, Control and Operation (SICO) drawings shall be supplied by the equipment and/or subsystem supplier/assembler under the overall responsibility of the air conditioning subcontractor.

2. All control equipment for the various subsystems shall be supplied by a reputable firm properly established in the Republic of South Africa which has a proven track record of at least five years and which can demonstrate the reliability of the control system offered.

3. The control systems as indicated on the SICO drawings shall include all controllers and controlling devices, specified or implied, to perform specified functions.

4. The control devices with their control action, performance and safety settings shall be installed and connected to perform the functions and operate in their required sequence as detailed on the SICO drawings.

5. At the time of equipment submission, the subcontractor shall provide complete documentation for each component or assembly of components in the subsystems.

6. The installation in its entirety shall comply with regard to electrical safety and supply interference suppression requirements, with SABS and/or local authorities by-laws and/or Post Office regulations.

7. The equipment shall be so constructed and components installed and connected and required spares available so that the maximum breakdown interference due to component replacement will be limited to one hour.

8. All items of the installation shall be readily accessible and connected for quick and easy replacement. Adequate space shall be provided around all items for easy removal of parts.

9. Materials and apparatus shall be in accordance with the relevant SABS or BS Standards.

10. Every care shall be taken to protect material, either fixed or unfixed, from damage, ingress of dust and moisture. The entire installation shall be in "as new" condition at handover.

11. Each controller and control device for all subsystems shall be provided with instruments (pressure gauges, volt meters, pilot lights, etc.), to show at the controller or control device location, the condition of the power supply to the controller and control device and the point within its control range at which the controller or control device is operating.

12. Where indicated for individually mounted controllers or control devices, the instruments may be permanently mounted or a portable instrument may be supplied for each 12 of such controllers or control devices, but not more than 4 such instruments will be required in one building.

13. At each controller for which portable instruments are to be used, means shall be provided for attaching and disconnecting the instrument without the use of tools (other than for removal of covers) and without breaking control lines.

14. Pressure gauges for individually mounted controllers shall be stem mounted, 40 mm large in diameter, with black finished cases. Individual gauges for panel mounted controllers shall be 50 mm in diameter with black or plated finish. Gauges for multiple indication or panel mounted controllers shall be 120 mm in diameter, with black or plated finish.

15. A thermometer pocket shall be installed at or near each insertion thermostat, located so that a calibrated thermometer inserted there will accurately indicate the temperature surrounding the sensing element of the thermostat.
1. PERFORMANCE

1.1 GENERAL

1.1.1 The control system shall perform the control functions indicated and specified on the terminal control arrangement drawing.

1.1.2 The control system as indicated shall include all sensors, adjusters, controllers and controlling devices specified or implied to perform the specified function.

1.1.3 The supplier shall provide one testing unit which can be used to simulate and check calibration of the controllers listed below. The testing unit shall plug into the same sensor plug.

1.2 OPERATING RANGE

1.2.1 The temperature adjustment shall have an operating range of 19°C to 24°C.

1.2.2 The proportional band and setpoint shall be as indicated on the terminal control arrangement drawing.

1.3 SAFETIES AND ALARM

1.3.1 All equipment shall be capable of withstanding a fault level of 5 kA.

1.3.2 All control circuits shall be isolated from the mains supply.

1.3.3 All controllers shall be protected against damage and protect direct power controlled elements.

1.3.4 The control system shall be suitable for operating at the designed building voltage and shall accommodate possible variations of up to 10%.

1.3.5 In all cases the braiding of the braided cable shall be used to earth conductor and shall be securely connected to the earth pin of the plug or connector.

2. RELIABILITY AND AVAILABILITY

2.1 DOWNTIME

2.1.1 The system shall be engineered to allow a fault location or component replacement to take no longer than 15 minutes by a trained operator or inspector, using the simulator provided by the supplier of the control system.

2.2 COMPREHENSIVE MAINTENANCE AND SERVICE CONTRACT

2.2.1 The maintenance and service of the system shall form part of the Comprehensive Guarantee Contract and shall allow for faulty components to be maintained on a plug in plug out replacement basis whereby all components are repaired, tested and calibrated off site. [Refer PART C4.7]

2.3 DOCUMENTATION

The system shall be fully documented and the documentation [Refer Part C1.5 Section 18] shall include:

2.3.1 'Record' Drawings.

2.3.2 Spares and availability.

2.3.3 Tenant management procedures.

2.3.4 Trouble diagnostics.
3. TECHNICAL RESTRAINTS

3.1 GENERAL

3.1.1 Equipment shall comply with and be selected and designed in accordance with the relevant SABS or BS Specification applicable to each item of equipment.

3.1.2 Where a discrepancy may exist between relevant Specifications the subcontractor's Project Engineer shall consult the Consulting Engineering for a ruling.

3.1.3 Equipment where possible shall be of the same make, size and type to reduce total number of spares to be kept.

3.1.4 Calibration of the sensor preferably shall be possible at the sensor by control technician using thermometer and screwdriver only. In case of electronic thermostatic control calibration or change of sensor shall not require access for adjustment on control box in floor plenum.

3.1.5 Electronic component boxes, if offered, shall be factory calibrated and sealed.

3.1.6 All connectors shall incorporate a means of prevention of accidental unplugging or pulling out.

3.1.7 The system shall be engineered so as to make it impossible to incorrectly plug in various control components.

3.1.8 The sensors or thermostats shall be delivered to site complete with wire tail fitted with plug in connector. The connector shall be suitably sized to allow it to pass through a 20mm diameter conduit incorporating a 45° bend.

3.1.9 The temperature sensor device shall be suitable for mounting on a standard 60mm dia drawbox to contain the temperature sensor. It shall be equipped with a set point adjuster of ± 20 mm in diameter, which the occupant can adjust from 19°C to 24°C. The set point adjuster shall be marked with indication for "warmer" and "cooler" and direction arrows.

3.1.10 The temperature setting knob of the sensor shall be readily accessible and the setting reading shall be clearly visible without removal of the external cover plate.

3.2 FAN AIR TERMINALS

3.2.1 A controller shall control the fan motor speed of the fan air terminal(s) from minimum to 100% proportional when the room temperature varies through a maximum of 2°C. The controller shall control from 1 fan air terminal up to a maximum of 6 slaved fan air terminals without varying the control characteristic as the quantity varies.

3.2.2 It shall be possible to pre-set the minimum and maximum motor speed levels from 10 - 80% of full speed.

3.2.3 The method of speed control for fan air terminals shall be approved by the fan air terminal motor manufacturer and shall be certified not to affect the guaranteed fan service life.

3.3 FAN HEATERS

3.3.1 Fan heaters shall be controlled by same controller that serves the fan air terminals in the room.

3.3.2 Each thermostat shall be capable of controlling up to 6 (six) fan heaters with the understanding that each fan heater shall have its own power supply.

3.3.3 The heating output shall be proportional from 0 - 100 % when the room temperature varies by 2°C.
3.4 VARIABLE VOLUME AIR TERMINALS

3.4.1 The temperature controller shall be of the microprocessor type using digital technology and having the facility to plug in a communication card so as to enable central interrogation and set point adjustment.

3.4.2 The temperature controller shall:

3.4.2.1 Vary the damper position from minimum to maximum in a proportional way when the room temperature varies through 2 °C from the set point

3.4.2.2 Provide proportional heating output when the room temperature varies through 2 °C below set point

3.4.2.3 Automatically detect and change over from summer and winter operation by sensing the supply air temperature and comparing this to set point

3.4.2.4 Have communication facilities for building management system control applications so as to shed heaters or limit output, change set point external, and control damper and heater

3.4.2.5 A remote temperature and set point adjuster in a range not exceeding 19 °C to 24 °C.

3.5 VARIABLE VOLUME PACKAGE UNIT CONTROLLER

3.5.1 The unit controller shall be of the programmable microprocessor type using digital technology.

3.5.2 The unit controller shall:

3.5.2.1 Vary the chilled water cooling valve using P, PI or PID control so as to maintain the supply air temperature at the selected set point

3.5.2.2 Vary the speed of the supply air fan using P, PI or PID control so as to maintain the static pressure as sensed by the static pressure sensor in the ductwork

3.5.2.3 Reset the supply air temperature in a proportional way from 10 to 18 °C when the return air temperature varies from 24 to 20 °C

3.5.2.4 Have communications facilities for a building management system so as to change supply, return air temperature, static pressure set points, activate/deactivate the unit, and modulate the cooling valve

3.5.2.5 Have built in run down timer on receiving stopping signal so as to prevent heating safeties tripping unnecessarily on VAV diffusers

3.5.2.6 Have a built in facility for plugging in hand held terminal or built in screen with key pad to adjust all the set points and read the status if all sensors and controlled elements.

3.6 CONSTANT VOLUME PACKAGE UNIT CONTROLLER

3.6.1 The unit controller shall be of the programmable microprocessor type using digital technology.

3.6.2 The unit controller shall:

3.6.2.1 Open the cooling valve when the return air set point is exceeded, and close the cooling valve if the return air or plenum temperature set points are reached

3.6.2.2 Have communication facilities for a building management system so as to change the set points and range of the return air and plenum air temperatures, as well as read actual values being sensed, activate/deactivate unit, control cooling valve, and indicate tripping of safeties
3.6.2.3 Have a built in facility for plugging in hand held terminal or built in screen with touch pad to adjust all the set points and read status of all sensors and controlled elements.

3.7 CONCEALED CEILING MOUNTED FAN COIL UNIT WITH INTEGRAL HEATER

3.7.1 A controller shall control the unit as follows:

3.7.1.1 1st step - Heating - Solenoid valve "CLOSED" Heating elements "ENERGISED"

3.7.1.2 2nd step - Cooling - Solenoid valve "OPEN"

3.7.2 The supply fan shall be activated as soon as the controller has been energised.

4. BUILDING RESTRAINTS

4.1 All underfloor components shall be sealed, drip and splash proof.

4.2 Underfloor components shall be designed to be able to withstand a load of 90 kg evenly distributed over the top area of the component assembly, without showing any signs of structural distortion or a permanent set.

4.3 The braided cable fixing shall be secured to all components by means of a gripper gland, capable of withstanding a straight pull of 30 N (± 3 kg), without any sign of damage to the cable or gland and without effecting the connection inside the component.

4.4 All underfloor components shall be raised 15 mm off the slab with the exception of braided cable which may be loosely run in the floor void.

5. MEASUREMENT TO CONFIRM COMPLIANCE WITH SPECIFICATION

5.1 The Subcontractor shall successfully demonstrate to the Engineer by means of working samples that each of the control functions can be satisfactorily performed in accordance with the previously approved submittals prior to any component manufacture.

5.2 No time is available for "on-site" functional testing of components, therefore on completion of manufacture all control components shall be fully tested for proper functioning prior to leaving the factory.

5.3 The following tests shall be performed in the factory by the manufacturers:

5.3.1 Earth test.

5.3.2 Function of equipment on a Consulting Engineer approved test rig Calibration setting. Interchangeability and compatibility of plug-in components Polarity of components.

5.4 The results of the above tests for each component shall be documented in a formal written test report and shall be signed by the manufacturer and the control engineer and shall be countersigned and accepted by the air conditioning Subcontractor's Project Engineer.

5.5 On completion of installation each control system shall be fully tested for functional performance and a written handover/test report for each system signed by the air conditioning Subcontractor's Project Engineer shall be handed over to the Consulting Engineer.

5.6 No acceptance or handover of the system will take place without the acceptance by the Consulting Engineer of the formal report.
1. PERFORMANCE

1.1 FUNCTION PERFORMANCE

1.1.1 The supervisory control system shall be configured in three levels each with their own set of functions:

1.1.1.1 Management Level

There shall be one PC based operator workstation which provides means to:

a) Supervise the system performance and status in the form of dynamic graphics and point status lists.

b) Prepare status reports, log sheets and provide a hard copy thereof on separate printers.

c) Execute integrated software packages to manage the system with regard to inter alia, operation, energy management and maintenance etc.

d) Implement, install and adapt all software packages including standard packages as specified in the bill.

e) To change set points and read the local set points of subsystem controllers and to communicate with outstations.

f) To acknowledge and prioritise alarms and route messages.

g) To interface and communicate with other systems e.g. fire, access control, etc.

h) Have the facility to be connected to a remote operator station via auto dial system using the telephone network.

1.1.1.2 Outstation Level

The intelligent outstation(s) are connected to management level and the subsystem interfaces (one or more sub- systems can be managed by one outstation) and shall:-

a) Perform all system management, allocated control and monitoring functions assigned to it independent of management level.

b) Have a self-analysis feature and transmit any malfunction message to management level.

c) Have a facility for accessing local and other outstation data information locally via a portable plug-in field console or a similar permanent device.

1.1.1.3 Stand Alone Controller / Local Processing Level

The standalone microprocessor based plug-in modules are connected to the outstations and typically control peripheral devices, elements and components in a subsystem and shall:-

a) Perform the control logic as indicated and specified on the Safeties, instrumentation Control and operation (SICO) drawings independent from higher processing levels or management level.

b) Provide means to change setpoints, integrating and differentiating time, and proportional bands through portable plug-in operator terminal.

c) Transmit all data to the outstation.
1.1.2 The control system shall be engineered and arranged in such a way that staged start-up at sub-system level is provided for staged commissioning.

1.1.3 Applications Programmes

1.1.3.1 General

A minimum set of programmes, as outlined below, shall be provided.

1.1.3.2 Calculations

This programme shall automatically perform predefined calculations based on operation input, real-time data and required constraints. Calculations shall include, but not limited to, the following: Enthalpy, relative humidity, wet bulb, water flow, electrical power, building load, etc. with any input data to the system.

1.1.3.3 Energy Management and Direct Digital Control Routines

This programme shall be capable of monitoring the rate of power consumption and shall take corrective action to avoid high penalty charges by shedding electrical loads when the pre-set demand level any particular time is projected to be exceeded.

a) There shall be a minimum of 8 levels of priority for loads available to be shed in both a heating and cooling mode.

b) The order of priority in each level shall be rotated to prevent any single load in a priority level from always being shed first.

c) A log shall be available to monitor the consumption profile over each demand period.

d) The system shall employ a floating demand set point which will adjust by a set percentage until the optimum set point is determined.

e) An operation alarm will be produced in case power demand is projected to be exceeded.

f) Load/comfort protection

1.1.3.4 Load Cycling

This programme shall be capable of cycling loads to reduce electrical consumption.

a) The programme shall have an operator defined minimum on time, minimum off time and maximum off time.

b) A temperature detector shall be assigned to each plant on the load cycling programme. Should the space temperature exceed pre-set limits the load cycling shall be overridden and the plant returned to the time control programme until the space temperature has returned to an acceptable level.

1.1.3.5 Sequential Starting

To prevent all loads from energising simultaneously on start-up, the program shall start loads sequentially as though the loads were being restored after a demand peak to assure an orderly start-up whether accomplished manually or after a power outage.
1.1.3.6 Hardware Programmes

Following software packages shall be provided and implemented by means of pull-down menus for all subsystems:

a) Print interlocking
b) Stop/start scheduling
c) Maintenance logging and scheduling
d) Chart recorder type trend logging
e) Statistical and computational package
f) Inventory control
g) Historical data/profiles and totalization
h) Trend on disc
i) Time/auto clock calendar, daily, weekly, monthly, yearly, programming of subsystems
j) Messages and alarms
k) Run time totalization
l) Report generation
m) Control commands on variables/elements in subsystems
n) Colour graphic generation of subsystems displays
 o) Continuously self-tuning Proportional Integral Derivative control algorithms

1.2 OPERATING RANGE

1.2.1 Sensitivity, speed of response and throttling range of the individual items of the control system shall be adjustable so that the controllers maintain steady conditions without hunting or drifting within the specified control values.

1.3 SAFETY AND ALARM - ABNORMAL CONDITIONS

1.3.1 In case of any control system malfunctioning or function interruption, an alarm signal shall be given by field adjustable, programmable, audible and visual alarms and the control device must remain in its last controlled position prior to the failure.

1.3.2 There shall be at least 4 levels of alarm. Levels 1 + 2 shall be critical alarms and levels 3 + 4 shall be non-critical. A level 1 alarm shall take precedence over a level 2 or lower alarm, a level 2 alarm shall take precedence over a level 3 alarm.

1.3.3 It shall be possible to prioritise alarms for specific programmed actions.

1.3.3.1 Critical alarms shall be indicated by an Audible tone and shall be displayed in red on the monitor. Non-critical alarms shall be indicated by a different audible tone and shall be displayed in orange on the monitor.

1.3.3.2 Alarms shall be printed as they occur on hard copy showing time, date and nature of alarm. Operator acknowledgement of alarms shall also be printed with the time and date.

1.3.3.3 Points in alarm shall be accessed on the monitor by using menu on screen.

1.3.3.4 Transient alarms shall be inhibited for a Selected Time period.

1.3.3.5 Alarms shall be automatically locked out to prevent nuisance alarms when plant is command "off". The operator shall have the ability to set selected Operating Alarm inhibit time periods when plant is initiated "on".

1.3.3.6 There shall be a minimum of 2000 extended text messages available to be assigned to any point or number of points. Any message shall have minimum of 10 lines. The message output shall be either event or time initiated.
1.3.4 All necessary features shall be built into the system to prevent the system being unintentionally commanded to perform undesirable functions. All necessary key locks and other measures such as multi-level code words shall be provided so that unauthorised personnel cannot change key parameters associated with control points that could cause undesirable malfunctioning of the air conditioning system.

1.4 SYSTEM OPERATION - OPERATOR INTERFACE

1.4.1 The control system Contractor shall submit the job description and required qualification of the system operator(s) together with full details of the training procedures and training aids.

1.4.1.1 Three full sets of manuals shall be provided such as:

a) Operator's Manual  
b) Engineer's Programming and Language Manuals  
c) Software Manual  
d) Trouble Diagnosis, Service and Maintenance Manual  
e) Quick Reference Manual  
f) System Technical Manual

1.4.2 All software shall be field proven and shall be demonstrated on similar systems before an order is placed.

1.4.3 The system shall have a flexible software package to allow an operator with minimal knowledge of software programming to construct unique programmes for plant control and management information.

1.4.3.1 The package shall provide, but not be limited to, the following functions.

a) Auto-changeover of pumps, fans etc on time programme, hours run or event (Pump and trip etc).  
b) Damper enthalpy override.  
c) Degree day calculations.  
d) Efficiency calculations.  
e) Time delays and sequenced interlocks.  
f) Cost savings calculations.  
g) Building load calculations

1.4.3.2 All programming shall be done in English language.

1.4.3.3 The system shall hold a complete set of help instructions in the software which can be viewed by the operator whilst in this operating mode.

1.4.3.4 The system shall provide run simulation of the programmes to allow operator verification before the programme is transmitted to the outstation.

1.4.4 All communications between the operator and the system shall be in English language and by using the mouse and keyboard.

1.4.5 Multiple level of password access shall be available to prevent unauthorised usage. A minimum of 20 Alpha-numeric passwords of up to 10 digits shall be provided. Each password shall be assignable to any of 20 levels of authority. When the system has not been used by the operator for a definable time period, e.g. 15 minutes, the password shall be automatically cancelled to prevent unauthorised persons tampering with the system. The password shall not display on the monitor when being entered by the operator.
1.4.6 The system shall monitor the status of plant via volt-free contacts from the motor starter panel or from differential pressure switches across fans, pumps, etc.

1.4.6.1 The operator shall have the option of receiving alarms on change of state or not.

1.4.6.2 The system shall have the capability of automatically totalising the hours run of the plant.

1.4.6.3 The system shall be capable of setting three alarm limits on hours run totals of each point and output a maintenance message on the pre-set total being reached.

1.4.7 The system shall continually monitor all analogue points such as temperature, pressure, relative humidity, etc., and display the current data on operator request.

1.4.7.1 The data displayed shall be in the engineering units of the measured variable, °C %RH, kPa, V, A, etc.

1.4.7.2 It shall be possible to set an alarm window of high and/or low limit alarms. When the measured value exceeds the limits an alarm shall be displayed.

1.4.7.3 It shall be possible to reference analogue alarms to command points to override the time or duty cycling programmes to preserve low limit temperature and provide for frost operation of plant.

1.4.8 Point Address shall be on four levels.

1.4.8.1 Level One shall identify the Service.

1.4.8.2 Level Two shall identify the Subsystem.

1.4.8.3 Level Three shall identify the Subsystem element.

1.4.8.4 Level Four shall identify the Element Point Number.

Operational Software point addressing shall be unrelated to the Hardware Address point in the Associated Outstation, to provide total flexibility.

1.4.9 The system shall monitor and record field information in the following four ways.

1.4.9.1 Plant Log

Status of subsystem shall be logged as selected by the operator. It shall be possible to select subsystem randomly, without limit up to the maximum number of plants on the system.

a) The logging interval shall be independently selectable for each plant from 0-24 hours in at least 2 minute increments.

b) The Subsystem Log shall be initiated and terminated by the Subsystem Log dedicated function key.

1.4.9.2 Trend Log

a) Operator Level

Data shall be stored in RAM for a specific period and then on disk when that period is exceeded. It shall be possible to:-

i) recall all such data for interactive graphic display on the monitor on a point by point basis.

ii) select multiple sets of trended data for down loading to a printer.
b) **Outstation Level**

Data for preselected points shall be stored in RAM for a specific period. It shall be possible to:

i) recall all such data for interactive graphic display on the monitor on a point by point basis.

ii) download the trended data to a printer.

c) The logging interval shall be selectable from 0-2 hours in 1 minute increments on the mass storage device, based on the principle that if no storage space exist that last into is automatically erased.

1.4.10 **Log Data Sets**

It shall be possible to create a minimum of 10 independent log data sets used to control the flow of logged data from outstations to management level.

1.4.10.1 The maximum log storage shall depend on the type of data being logged, number of points, frequency of events and duration. It shall be possible for the operator to size the Log Data Sets and have the ability to transfer stored data from the system Operating disk to a storage medium (floppy disks available on the local market) for archive purposes.

1.4.10.2 Each Log Data Set shall specify the type, or set, of the points.

1.4.10.3 The transmission of logged data shall be in the order of priority assigned to each outstation.

1.4.10.4 A selective printout of any log, or logs or part of any log may then be taken at management level.

1.4.10.5 All printouts taken of logs shall indicate the time and date.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWNTIME**

2.1.1 The equipment shall be so constructed and components installed, connected and documented so that with required spares available - and diagnosis methods used, the maximum breakdown interference for any card or board replacement will be limited to one hour.

The control system Contractor shall demonstrate at stage of tendering how the "Mean Time To Return" the system to its operational status is achieved with the aid of trouble shooting flow charts to diagnose and repair the sub-system.

2.1.2 During pre-handover (commissioning and testing) "Downtime" of the control system and/or during actual "Downtime" during the period that the Comprehensive Service and Maintenance Contract is in force, the control system Contractor shall operate the entire system (in close co-operation with the air conditioning Sub-contractor, when appropriate) for as long a period as may be required to provide satisfactory performance at all times in the occupied spaces served by that system for up to 24 hours a day continuously.

The control system Contractor shall provide the operator(s) and equipment required for testing and operating the system. The employer may assign operating personnel as observers but such observation time shall not be counted as instruction time.

The control system Contractor's operator(s) shall be fully conversant with the system operation and experienced in running similar installations.
2.2 MEAN TIME BETWEEN FAILURES

2.2.1 The Mean Time between failure of the overall system or parts of the system shall be a minimum of 7.5 years. Not more than 5% of the system components shall fail in any one year.

2.3 COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACT

2.3.1 Only control firms, well established in the RSA, regularly engaged in the installation and maintenance of these systems and who submit proof that they can (and will) honour a 5 year (renewable to 10 years) Comprehensive Service and Maintenance Contract as defined in Part C3.2 Clause 11 at an acceptable price, will be considered as an acceptable Subcontractor.

2.4 DOCUMENTATION

2.4.1 At tender stage the control system contractor shall submit his interpretation of the point list, major qualifications and brief summary of the proposed system offered.

2.4.2 The control system Contractor shall submit at equipment submission stage full details of his proposed:

- Fault detection and identification methods
- Fault correction methods
- Spare parts availability
- Documentation
- Operator's and Maintenance training.

2.4.3 During construction, prior to handover full Operating, Trouble Diagnosis, Service and Maintenance Manuals, together with training aids and procedures shall be submitted.

2.4.4 The control system Contractor shall submit full details how and what integrity checks are continuously performed concurrent with normal operation and the subsequent actions shall be fully described and the influence of these procedures on achieving the claimed “Mean Time to Return” to normal operation.

2.4.5 Software control programs shall be capable of being saved onto or loaded back from storage devices. Proper error checking and data verification modes shall exist to ensure data integrity.

3. TECHNICAL RESTRAINTS ON SYSTEM AND COMPONENTS

3.1 EQUIPMENT REQUIREMENTS

3.1.1 General

3.1.1.1 The control system hardware shall be readily accessible, modular, plug-in connected, to allow for easy fault diagnosis and ease of maintenance on a remove and replace basis to limit downtime to minimum. Adequate space shall be provided around all items for easy removal of parts.

3.1.1.2 System shall have self-diagnostic characteristics to determine fault conditions.
3.1.2 Hardware

The hardware should be configured in the following levels:

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>HARDWARE</th>
<th>REFER</th>
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</thead>
<tbody>
<tr>
<td>Management level</td>
<td>Standard IBM or fully compatible personal computer with 104 keyboard.</td>
<td>Section 3.2</td>
</tr>
<tr>
<td>(Operator workstation)</td>
<td>Hard disk, CD and USB Ports.</td>
<td></td>
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<tr>
<td></td>
<td>LED VGA or HD compatible screen - size 23” minimum.</td>
<td></td>
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<tr>
<td></td>
<td>Communication network.</td>
<td></td>
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<tr>
<td></td>
<td>High speed printer.</td>
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<td></td>
<td>Logging printer.</td>
<td></td>
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<tr>
<td></td>
<td>DSL/GSM modem</td>
<td></td>
</tr>
<tr>
<td>Outstation level</td>
<td>Stand-alone intelligent programmable supervising controller.</td>
<td>Section 3.3</td>
</tr>
<tr>
<td></td>
<td>Interface to other out-station, stand alone and management level.</td>
<td></td>
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<tr>
<td></td>
<td>Field plug-in console.</td>
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<tr>
<td>Stand-alone level</td>
<td>Stand-alone field gear.</td>
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<tr>
<td></td>
<td>Local processors.</td>
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<td></td>
<td>Peripheral devices (valves sensors, etc)</td>
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<tr>
<td></td>
<td>Terminal controllers.</td>
<td>Section 3.4</td>
</tr>
<tr>
<td></td>
<td>Programmable system controllers.</td>
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<tr>
<td></td>
<td>MCC start/stop monitoring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subsystem interface panels with other services.</td>
<td></td>
</tr>
</tbody>
</table>
3.2 OPERATOR WORKSTATION

The Operator workstation shall comprise of a standard IBM or fully compatible personal computer with a hard disk, keyboard, USB Ports and DVD unit, LED VGA or HD compatible monitor and high speed printer. The PC shall have the capability to connect a second High Speed Printer or Trend Recorder and shall also have the facility for an DSL/GSM modem and/or internet connection.

3.2.1 The personal computer shall communicate with the outstations and process data received from the field for operator use via a communication buss or local area network. All output and input shall be in English Language.

3.2.1.1 The processor shall be a Core i5 3.2GHz or better.

3.2.1.2 It shall have an on board RAM, 4GB or better to cater for the software implied or specified.

3.2.1.3 It shall have a internal surveillance system to detect hardware or software failure.

3.2.1.4 Communication to the outstations shall be on a high speed Local Area Network or communication buss which can have a minimum distance capability of 1km. The system shall have an error checking facility to ensure the integrity of transmitted data. Corrupted messages shall be automatically repeated. The Baud rate shall be adjustable between 9600 and 38400 or more.

3.2.1.5 The Autodial Modem at the operator station shall be capable of Multiple Line Connection supporting up to 3 Telephone Numbers. Control shall be structured so that the system can communicate over other lines should one become defective or busy. The DSL/GSM router shall be capable of automatic change over should the DSL network be unavailable.

3.2.1.6 Operating system shall be based Windows based and the latest version available shall be used.

3.2.2 Mass Storage Devices

The storage devices must consist of:

3.2.2.1 Hard Disk minimum 500GB

3.2.2.2 USB Ports and Compact Disk Unit:

The Disk Units shall be used to load the operating software on system initialisation and to retrieve and store historical data for future processing. It shall have a minimum storage of CD drive 52 x speed for the CD drive. On-board USB ports shall also be available.

3.2.3 Monitor

The monitor shall be the high definition colour graphics type with a minimum pixel density of 1920 x 1080 pixels.

The colour graphic card shall have be high definition.

3.2.4 Operator's Keyboard / Pointing Device

The Operator's Keyboard shall be a 104 keyboard.

The serial mouse shall be compatible with window software applications.
3.2.5 High Speed Printer and Logging Printer

The Printers shall print at least 75 characters per line on standard A4 paper using a dot matrix system. It shall be possible to connect up to 2 printers to the System. The printing speed should be 300 characters per second or more. The printer should have an option to print Near Letter Quality (N.L.Q.).

It shall be possible to Route Alarms and associated messages, Reports, Logs, etc., to selected printer or printers. Alarm routing may be in accordance with priority level and Time of Day.

3.3 OUTSTATIONS

Outstations shall be of the fully intelligent microprocessor based, capable of performing all Management functions assigned to them, independent of management level.

3.3.1 Outstations shall be modular in construction with plug-in function cards in any combination of analogue, digital inputs or outputs.

3.3.2 Outstations shall be able to handle the specified or implied points for the outstation plus 10% spare capacity.

3.3.3 Outstations shall have battery back-up to support the outstation in full operation for a period of 72 hours in the event of localised mains failure, but the battery shall not supply power to actuators for valves, dampers etc. A battery back-up for the memory alone is not acceptable. The battery status must be logged during printouts.

3.3.4 The outstation shall be able to cater for at least 200 points via plug-in modules/cards.

3.3.4.1 COMMAND POINTS. Digital outputs shall provide electrically maintained signal to operate low voltage relays for starting and stopping subsystems.

3.3.4.2 STATUS POINTS. Digital inputs shall monitor volt-free contacts in MCC's via interface strips or interface panels.

3.3.4.3 ANALOGUE MONITORING POINTS. Analogue inputs shall be capable of accepting typically signals of 0-10Vdc, 4-20mA or 0-10K ohms. The specialist BMS Manufacturer shall provide suitable sensors and transducers to carry out the analogue monitoring shown on the SICO drawings.

3.3.4.4 ANALOGUE OUTPUT POINTS. Shall be 4-20 mA or 0-10Vdc proportional signals sourced internally or externally.

The specialist BMS manufacturer shall provide suitable actuators for valves, dampers, etc., to carry out the analogue control shown on the SICO drawings.

3.3.4.5 PULSE COUNTING POINTS. Modules shall read pulse signals up to 32 kHz.

3.3.5 Where a common point such as Maximum Demand Meter input relevant to a specific outstation is used by another outstation, the outstation shall transmit the current values to management level or to other outstations using that information.

3.3.6 All software required to perform the operational functions of the system under normal operation shall be resident in the outstation.

3.3.7 In the event of mains failure at the outstation exceeding the battery support time, the outstation memory shall be reloaded automatically from management level on restoration of power.

3.3.8 In the event of management level or communication failure, alarms reports and logs shall be stored at the outstation and transmitted to the management level on restoration of communication.
3.3.9 Outstations requiring fan cooling are not acceptable. Outstations must be capable of meeting IP54 standard.

3.3.10 There shall be the facility for accessing outstation data information locally, via a portable plug-in Field Console which can be common to all outstations and normally removed to prevent unauthorised tampering. This unit shall have password access.

3.4 STAND ALONE CONTROLLER LEVEL AND INTERFACE

3.4.1 The system shall be designed to utilise only standard sensors, controllers transducers, servo actuators, for the industry which have been field tested for at least 2 years. The control system shall not only incorporate its own sensors and controllers where applicable, but shall also use the standard instrumentation, sensors and control equipment supplied as "standard" on equipment such as chillers, in order that the performance of all the components of a subsystem can be test logged and commanded at the central operator's terminal.

3.4.2 All actuators, operating valves, dampers, etc., controlling the capacity of components and/or subsystems shall be equipped with manual operators to maintain control during power failure or interruption. It shall be impossible to use the manual operator when the power is switched on. If the actuator is switched back to automatic control the manual operator knob shall automatically disengage.

3.4.3 All interface between sensors, components, relay boards, capacity controllers, etc., shall be via plug-in-terminal-factory pre-tested connector strips in the MCC's or interface panels.

3.4.4 The accuracy of the sensors, controllers, outstations and management level shall be of such a standard that the discrepancy (measuring error) between actual and measured value never exceed 2% of the operating range specified on the SICO drawings.

4. BUILDING - AUTHORITIES RESTRAINTS ON SYSTEM

4.1 RESTRAINTS IMPOSED ON SYSTEM

4.1.1 Every care shall be taken to protect material, either fixed or unfixed, from damage, ingress of dust, water and moisture. The entire installation shall be in "as new" condition at handover.

4.1.2 Cabling between the end of a conduct and an instrument shall be installed in sprague tubing. The termination of the Sprague between the conduit and the instrument shall prevent ingress of dirt, water, moisture, etc.

4.1.3 All panels shall be totally enclosed, dust, damp and vermin proof.

4.1.4 System shall be designed for location in mechanical plantrooms. Maximum temperature 40°C.

4.1.5 The system shall be designed to provide continuity and correct operation during abnormal conditions caused by over voltages, electromagnetic induction, spiking input/output and any other "normal" interference found in commercial buildings through switching of fluorescent lights, operation of other control equipment, operation of welding machines, somewhere in the building, etc.

4.2 AUTHORITIES

4.2.1 The installation in its entirety shall comply with regard to electrical safety, supply interference and suppression requirements, with SABS and/or local, supply authorities, By-laws, and/or Post Office regulations.
5. "MEASUREMENT" TO CONFIRM SYSTEM COMPLIANCE WITH SPECIFICATION

5.1 After successful demonstration of control operation of each sub-system including accuracy of sensors, a total system demonstration shall be performed. This demonstration, having satisfactorily met previously approved submittals, shall with the Engineer's written acceptance, allow commissioning of the system for on-line operation.

5.2 The control system will only be taken over by the Client after the following has been successfully completed by the control system Contractor:

5.2.1 Training of the system's operator and demonstration that the operator is fully conversant with the system trouble diagnosis and corrective actions.

5.2.2 Test printout logs for all sub-systems demonstrating that the sub-systems have been properly commissioned and that the complete air conditioning system and the control system is functioning properly for at least a 4 week period without any system downtime.

5.3 The printer at the operator's terminal shall also twice daily provide logging printout to monitor input and output interface of each sub/system to prove the system is functioning in accordance with the control system.

5.4 All instrumentation data indicated on the SICO drawings and marked for remote indication shall appear on the printout log under the SICO instrument coding. Accuracy of instrumentation shall comply with Part C3.2 Clause 5.

5.5 The proper functioning of the entire supervisory control system shall be documented in a formal handover/test report written and signed by the control system's responsible Engineer and accepted and countersigned by the air conditioning subcontractor's Project Engineer.

5.6 The control system tenderer shall submit his pro-forma test/handover report at tendering stage.

5.7 No handover of system will take place without submission to - and acceptance by the Consulting engineer of this formal handover report.

6. MONITORING SCHEDULE

6.1 GENERAL WORKS

6.1.1 The quantities shown in the quantity schedules on pages V.4/58, V.4/59 and V.5/60 are our interpretation of requirements to comply with the intent of the SICO drawings.

6.1.2 Should the offered equipment/system require more or less points, then the schedules of quantities shall be adjusted accordingly.

6.1.3 Where indicated "other" under field sensor means that for these items the necessary sensors and transducers are provided by the electrical, fire, etc., contractors. These points will be wired by them to and terminating in a terminal strip as described in Part C3.3 of the specification.

6.1.4 All field sensors provided by the other contractors will comply with the specifications mentioned.
## BUILDING MONITORING SCHEDULE

### PAGE OF FUNCTION LEGEND

<table>
<thead>
<tr>
<th>A</th>
<th>S</th>
<th>S/S</th>
<th>C</th>
<th>M</th>
<th>S/P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM (= CONTROL)</td>
<td>STATUS (ON/OFF OR OPEN/CLOSE)</td>
<td>START/STOP</td>
<td>CONTROL</td>
<td>MONITORING</td>
<td>SETPOINT</td>
</tr>
</tbody>
</table>

### QUANTITY SCHEDULE

**Legend**

- **R** = RELAY
- **DO** = DIGITAL OUTPUT
- **DI** = DIGITAL INPUT
- **AO** = ANALOGUE OUTPUT
- **AI** = ANALOGUE INPUT
- **VFC** = VOLTAGE FREE CONTACT
- **ES** = SENSOR ON SUPPLIED EQUIPMENT
- **P** = PULSE

<table>
<thead>
<tr>
<th>No</th>
<th>Equipment Description</th>
<th>Engineering units</th>
<th>Function</th>
<th>Field Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>MECHANICAL HVAC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Evaporative Condenser Unit (4 off)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>Floor Static Pressure Control (11 off)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>VRF SYSTEM (1 off)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated supply air temperature setpoints reset for average space temp.</td>
<td>°C</td>
<td>S/P</td>
<td>2</td>
<td>Software</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>----</td>
<td>-----</td>
<td>---</td>
<td>---------</td>
</tr>
<tr>
<td>Stop/Start pre-cool cycle</td>
<td>0/1</td>
<td>S/S</td>
<td>2</td>
<td>24V AC</td>
</tr>
<tr>
<td>Average space temperature</td>
<td>°C</td>
<td>M</td>
<td>2</td>
<td>Wall mount sensor</td>
</tr>
<tr>
<td>Outside air dew Points</td>
<td>°C</td>
<td>M</td>
<td>2</td>
<td>Calculated</td>
</tr>
<tr>
<td>Min. Outside air temperature (°C db) setpoints</td>
<td>°C</td>
<td>S/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Outside Air dew Points setpoints</td>
<td>°C</td>
<td>S/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Difference between outside air temp. and ave. space temp</td>
<td>°C</td>
<td>S/P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points per Single Unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for all unit/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Stop/Start pre-cool cycle**: 0/1 S/S
- **Average space temperature**: °C M 2
- **Outside air dew Points**: °C M 2
- **Min. Outside air temperature (°C db) setpoints**: °C S/P
- **Max. Outside Air dew Points setpoints**: °C S/P
- **Min. Difference between outside air temp. and ave. space temp**: °C S/P
- **Points per Single Unit**: 10 1 4 3 1 0 6 25
- **Total for all unit/s**: 20 2 8 6 2 0 12 50
- **Total**: 42 17 20 10 2 0 23 114
1. PERFORMANCE

1.1 FUNCTION PERFORMANCE

1.1.1 The stand-alone control system shall be of the direct digital control type and be configured with the following functions:

1.1.1.1 Stand Alone Controller / Local Processing Level

The stand alone micro processor based plug-in modules typically control peripheral devices, elements and components in a subsystem and shall:

a) Perform the control logic as indicated and specified on the Safeties, instrumentation Control and operation (SICO) drawings independent of higher processing levels.

b) Provide means to change setpoints, integrating and differentiating time, and proportional bands through portable plug-in operator terminal.

c) Transmit relevant data to other stand-alone controllers installed if required to do so.

1.1.2 The control system shall be engineered and arranged in such a way that staged start-up at sub-system level is provided for staged commissioning.

1.1.3 Applications Programmes

1.1.3.1 General

A minimum set of programmes, as outlined below, shall be provided.

1.1.3.2 Calculations

This programme shall automatically perform predefined calculations based on operation input, real-time data and required constraints. Calculations shall include, but not limited to, the following: Enthalpy, relative humidity, wet bulb, waterflow, electrical power, building load, etc. with any input data to the system.

1.1.3.3 Energy Management and Direct Digital Control Routines

A dedicated stand-alone controller shall be capable of monitoring the rate of power consumption and shall take corrective action to avoid high penalty charges by shedding electrical loads via interconnected stand-alone controllers when the pre-set demand level any particular time is projected to be exceeded.

1.1.3.4 Load Cycling

This programme shall be capable of cycling loads to reduce electrical consumption.

a) The programme shall have an operator defined minimum on time, minimum off time and maximum off time.

b) A temperature detector shall be assigned to each plant on the load cycling programme. Should the space temperature exceed pre-set limits the load cycling shall be overridden and the plant returned to the time control programme until the space temperature has returned to an acceptable level.
1.1.3.5 Sequential Starting

To prevent all loads from energising simultaneously on start-up, the program shall start loads sequentially as though the loads were being restored after a demand peak to assure an orderly start-up whether accomplished manually or after a power outage.

1.1.3.6 Software Programmes

Following software packages shall be provided and implemented by means of pull-down menus for all subsystems:

a) Stop/start scheduling.
b) Time/auto clock calendar, daily, weekly, programming of subsystems.
c) Control commands on variables/elements in subsystems.
d) Continuously self-tuning Proportional Integral Derivative control algorithms.

1.2 OPERATING RANGE

1.2.1 Sensitivity, speed of response and throttling range of the individual items of the control system shall be adjustable so that the controllers maintain steady conditions without hunting or drifting within the specified control values.

1.3 SAFETY AND ALARM - ABNORMAL CONDITIONS

1.3.1 In case of any control system malfunctioning or function interruption, an alarm signal shall be given by field adjustable, programmable, audible and visual alarms and the control device must remain in its last controlled position prior to the failure.

1.3.2 Points in alarm shall be accessed on the stand-alone controller by using menu on screen.

1.4 SYSTEM OPERATION - OPERATOR INTERFACE

1.4.1 The control system Subcontractor shall provide an operator terminal which will facilitate operation of the system using a display screen and keypad or touch screen.

1.4.2 The operator terminal shall provide as a minimum, access to:

1.4.2.1 Setpoints and variable parameters
1.4.2.2 Time schedules and clock functions
1.4.2.3 Manual operation, changes to time schedules of subsystems
1.4.2.4 Equipment status alarms

1.4.3 Operation of the operator’s terminal shall be through logical means to prevent incorrect operation and a minimum of three access levels shall be provided to protect against unauthorised access to values structured at high access levels.

1.4.4 The control system Contractor shall submit the job description and required qualification of the system operator(s) together with full details of the training procedures and training aids.

Three full sets of manuals shall be provided such as:

1.4.4.1 Operator’s Manual
1.4.4.2 Engineer’s Programming and Language Manuals
1.4.4.3 Software Manual
1.4.4.4 Trouble Diagnosis, Service and Maintenance Manual
1.4.4.5 Quick Reference Manual
1.4.4.6 System Technical Manual
1.4.5 All software shall be field proven and shall be demonstrated on similar systems before an order is placed.

1.4.6 Resident programmes shall provide, but not be limited to, the following functions.

1.4.6.1 Auto-changeover of pumps, fans etc on time programme, hours run or event (Pump and trip etc).
1.4.6.2 Damper enthalphy override.
1.4.6.3 Degree day calculations.
1.4.6.4 Efficiency calculations.
1.4.6.5 Time delays and sequenced interlocks.

1.4.7 The system shall monitor the status of plant via volt-free contacts from the motor starter panel or from differential pressure switches across fans, pumps, etc.

1.4.8 The system shall continually monitor all analogue points such as temperature, pressure, relative humidity, etc., and display the current data on operator request.

1.4.8.1 The data displayed shall be in the engineering units of the measured variable, °C, %RH, kPa, V, A, etc.

1.4.8.2 It shall be possible to set an alarm window of high and/or low limit alarms. When the measured value exceeds the limits an alarm shall be displayed.

1.4.8.3 It shall be possible to reference analogue alarms to command points to override the time or duty cycling programmes to preserve low limit temperature and provide for frost operation of plant.

2. RELIABILITY AND AVAILABILITY

2.1 DOWNTIME

2.1.1 The equipment shall be so constructed and components installed, connected and documented so that with required spares available - and diagnosis methods used, the maximum breakdown interference for any card or board replacement will be limited to one hour.

The control system Contractor shall demonstrate at stage of tendering how the "Mean Time To Return" the system to its operational status is achieved with the aid of trouble shooting flow charts to diagnose and repair the sub-system.

2.1.2 During pre-handover (commissioning and testing) "Downtime" of the control system and/or during actual "Downtime" during the period that the Comprehensive Service and Maintenance Contract is in force, the control system Contractor shall operate the entire system (in close co-operation with the air conditioning Sub-contractor, when appropriate) for as long a period as may be required to provide satisfactory performance at all times in the occupied spaces served by that system for up to 24 hours a day continuously.

The control system Contractor shall provide the operator(s) and equipment required for testing and operating the system. The employer may assign operating personnel as observers but such observation time shall not be counted as instruction time.

The control system Contractor’s operator(s) shall be fully conversant with the system operation and experienced in running similar installations.

2.2 MEAN TIME BETWEEN FAILURES

2.2.1 The Mean Time between failure of the overall system or parts of the system shall be a minimum of 7,5 years. Not more than 5% of the system components shall fail in any one year.
2.3 COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACT

2.3.1 Only control firms, well established in the RSA, regularly engaged in the installation and maintenance of these systems and who submit proof that they can (and will) honour a 5 year (renewable to 10 years) Comprehensive Service and Maintenance Contract (Refer Addendum H) at an acceptable price, will be considered as an acceptable Subcontractor.

2.4 DOCUMENTATION

2.4.1 At tender stage the control system contractor shall submit his interpretation of the point list, major qualifications and brief summary of the proposed system offered.

2.4.2 The control system Contractor shall submit at equipment submission stage full details of his proposed:
   2.4.2.1 Fault detection and identification methods
   2.4.2.2 Fault correction methods
   2.4.2.3 Spare parts availability
   2.4.2.4 Documentation
   2.4.2.5 Operator's and Maintenance training.

2.4.3 During construction, prior to handover full Operating, Trouble Diagnosis, Service and Maintenance Manuals, together with training aids and procedures shall be submitted.

2.4.4 The control system Contractor shall submit full details how and what integrity checks are continuously performed concurrent with normal operation and the subsequent actions shall be fully described and the influence of these procedures on achieving the claimed "Mean Time to Return" to normal operation.

3. TECHNICAL RESTRAINTS ON SYSTEM AND COMPONENTS

3.1 EQUIPMENT REQUIREMENTS

3.1.1 General

3.1.1.1 The control system hardware shall be readily accessible, modular, plug-in connected, to allow for easy fault diagnosis and ease of maintenance on a remove and replace basis to limit downtime to minimum. Adequate space shall be provided around all items for easy removal of parts.

3.1.1.2 System shall have self-diagnostic characteristics to determine fault conditions.
3.1.2 Hardware

The hardware should be configured in the following levels:

<table>
<thead>
<tr>
<th>Stand-alone controller level</th>
<th>Stand-alone field gear.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local processors.</td>
<td></td>
</tr>
<tr>
<td>Peripheral devices</td>
<td></td>
</tr>
<tr>
<td>(valves sensing, etc).</td>
<td></td>
</tr>
<tr>
<td>Terminal controllers.</td>
<td></td>
</tr>
<tr>
<td>Programmable system controllers.</td>
<td></td>
</tr>
<tr>
<td>MCC start/stop monitoring.</td>
<td></td>
</tr>
<tr>
<td>Sub-system interface panels with other services.</td>
<td></td>
</tr>
<tr>
<td>Touch screen operator terminal.</td>
<td></td>
</tr>
</tbody>
</table>

Section 3.2

3.2 STAND ALONE CONTROLLER LEVEL AND INTERFACE

3.2.1 The system shall be designed to utilise only standard sensors, controllers transducers, servo actuators, for the industry which have been field tested for at least 2 years. The control system shall not only incorporate its own sensors and controllers where applicable, but shall also use the standard instrumentation, sensors and control equipment supplied as "standard" on equipment such as chillers, in order that the performance of all the components of a subsystem can be test logged and commanded at the central operator's terminal.

3.2.2 All actuators, operating valves, dampers, etc., controlling the capacity of components and/or subsystems shall be equipped with manual operators to maintain control during power failure or interruption. It shall be impossible to use the manual operator when the power is switched on. If the actuator is switched back to automatic control the manual operator knob shall automatically disengage.

3.2.3 All interface between sensors, components, relay boards, capacity controllers, etc., shall be via plug-in-terminal-factory pre-tested connector strips in the MCC's or interface panels.

3.2.4 The accuracy of the sensors, controllers, outstations and management level shall be of such a standard that the discrepancy (measuring error) between actual and measured value never exceed 2% of the operating range specified on the SICO drawings.

3.3 POINT DESCRIPTIONS

3.3.1 COMMAND POINTS. Digital outputs shall provide electrically maintained signal to operate low voltage relays for starting and stopping subsystems.

3.3.2 STATUS POINTS. Digital inputs shall monitor volt-free contacts in MCC's via interface strips or interface panels.

3.3.3 ANALOGUE MONITORING POINTS. Analogue inputs shall be capable of accepting typically signals of 0-10Vdc, 4-20mA or 0-10k ohms. The specialist BMS Manufacturer shall provide suitable sensors and transducers to carry out the analogue monitoring shown on the SICO drawings.

3.3.4 ANALOGUE OUTPUT POINTS. Shall be 4-20 mA or 0-10Vdc proportional signals sourced internally or externally. The specialist BMS manufacturer shall provide suitable actuators for valves, dampers, etc., to carry out the analogue control shown on the SICO drawings.

3.3.5 PULSE COUNTING POINTS. Modules shall read pulse signals up to 32 kHz.
4. BUILDING - AUTHORITIES RESTRAINTS ON SYSTEM

4.1 RERAINTS IMPOSED ON SYSTEM

4.1.1 Every care shall be taken to protect material, either fixed or unfixed, from damage, ingress of dust, water and moisture. The entire installation shall be in “as new” condition at handover.

4.1.2 Cabling between the end of a conduit and an instrument shall be installed in Sprague tubing. The termination of the Sprague between the conduit and the instrument shall prevent ingress of dirt, water, moisture etc.

4.1.3 All panels shall be totally enclosed, dust, damp and vermin proof.

4.1.4 System shall be designed for location in mechanical plantrooms. Maximum temperature 40°C.

4.1.5 The system shall be designed to provide continuity and correct operation during abnormal conditions caused by over voltages, electromagnetic induction, spiking input/output and any other “normal” interference found in commercial buildings through switching of fluorescent lights, operation of other control equipment, operation of welding machines, somewhere in the building, etc.

4.2 AUTHORITIES

4.2.1 The installation in its entirety shall comply with regard to electrical safety, supply interference and suppression requirements, with SABS and/or local, supply authorities, By-laws, and/or Post Office regulations.

5. "MEASUREMENT" TO CONFIRM SYSTEM COMPLIANCE WITH SPECIFICATION

5.1 After successful demonstration of control operation of each sub-system including accuracy of sensors, a total system demonstration shall be performed. This demonstration, having satisfactorily met previously approved submittals, shall with the Engineer's written acceptance, allow commissioning of the system for on-line operation.

5.2 The control system will only be taken over by the Client after the following has been successfully completed by the control system Contractor:

5.2.1 Training of the system's operator and demonstration that the operator is fully conversant with the system trouble diagnosis and corrective actions.

5.2.2 The proper functioning of the entire stand-alone control system shall be documented in a formal handover/test report written and signed by the control system's responsible Engineer and accepted and countersigned by the air conditioning subcontractor's Project Engineer.

5.2.3 The control system tenderer shall submit his pro-forma test/handover report at tendering stage.

5.2.4 No handover of system will take place without submission to - and acceptance by the Consulting engineer of this formal handover report.

6. MONITORING SCHEDULE

6.1 GENERAL WORKS

6.1.1 Where indicated "other" under field sensor means that for these items the necessary sensors and transducers are provided by the electrical, fire, etc., contractors. These points will be wired by them to and terminating in a terminal strip as described in Part C1.5 Section 4 of the specification. All field sensors provided by the other contractors will comply with the specifications mentioned under clauses 3.3 of Part C3.3 Section 09.06.04.
1. PERFORMANCE

1.1 FUNCTION

The water conditioning programme shall be for the open and closed water systems, commencing with the start-up of the refrigeration and air conditioning equipment.

The water treatment programme shall provide the following, based on the parameters listed in the Schedule.

1.1.1 Corrosion Control

1.1.1.1 Corrosion control during the construction phase

Prior to the onset of construction, the services of a water treatment company/specialist shall be retained to ensure that corrosion does not occur prior to the commissioning of the system. This water treatment company/specialist shall submit a proposal of how corrosion is to be controlled prior to the commissioning of the system. A pro-forma certificate of handover shall also accompany this proposal in which the methods of corrosion prevention which have been implemented are listed together with an analysis of the system and guarantee that the system is free of corrosion. The dates of flushing and passivating the system together with the type and quantity of chemicals used for this procedure must also be included in this document.

The water treatment company/specialist will thus ensure that the system does not remain filled with untreated water for any length of time, especially after pressure testing.

1.1.1.2 Corrosion control following the construction stage

Demonstrate that the system has been properly commissioned, that the system and its control are functioning properly and that the system is stable for at least a 4-week period without any system downtime, malfunctioning or any significant fluctuations being observed in the water quality. During this 4-week period, water analysis shall be performed at least once a week to show that the system is stable and is functioning correctly.

1.1.2 Scale Control

1.1.2.1 Formation of adherent mineral deposits which cannot be flushed from heat transfer surfaces shall be prevented.

1.1.2.2 The water conditioning system contractor shall analyse and propose the optimum internal chemical treatment of water in the circuits to give the lowest annual cost of water and corrosion inhibitors.

1.1.3 Algae, Slime, Bacteria and Other Living Organisms Control

Algae, bacteria and slime growth shall be prevented in all circuits by using suitable algaecides/biocides.

1.1.4 Legionella Pneumophila

Sporing of Legionella Pneumophila shall be controlled in the cooling towers and open circuit sections of the condenser water system by automatic proportional dosing of a suitable biocide.
1.2 OPERATING RANGE

1.2.1 The water in both the closed and open systems shall be analysed at least once very second week for the open system and once a month for the closed system to ensure that the water quality within the system is acceptable. Apart from other parameters which the water treatment company/specialist might monitor, the total and soluble iron contents are also to be monitored so that corrosion within the system can be detected. The results of these analyses are to be used to ensure proper control of corrosion, scale, algae, bacteria and slime.

1.2.2 Overall corrosion and pitting rates shall be measured by suitable corrosion test coupons representing the metals in the circuit.

1.2.3 Apart from a copy of the analysis sheets remaining on-site, a full report detailing the state of the water treatment within that period will be submitted to the client at least every three months as part of their comprehensive service and maintenance contract. When the water treatment company/specialist is a Subcontractor, then these reports are to be submitted to both the contractor and the client. These reports are to include graphs of the relevant water quality parameters and corrosion rates so that trends in the water quality may be readily observed by personnel not skilled in the field of water treatment. These trends which are to span at least a year, where possible, must also be accompanied by a brief description of what is occurring within the systems as well as what the consequences of these trends would be.

1.3 SAFETY AND ALARM

1.3.1 Full details shall be submitted at equipment submission stage what safeties and alarms are provided to prevent corrosion damage to piping and equipment through misapplication of chemicals. Provide all relevant safety instructions adjacent to each dosing system with specific reference to chemicals and human interface.

1.4 EQUIPMENT SYSTEM OPERATION - OPERATOR/INSPECTOR INTERFACE

1.4.1 The water conditioning contractor shall provide manual instructions and suitable kits for operating personnel for the routine servicing, monitoring and inspection of the performance of the water conditioning programme.

1.4.2 The water conditioning contractor shall clean, disinfect and pre-treat the open sections of the air handling unit spray water system prior to start up of the cooling systems. Start-up shall occur immediately thereafter to avoid any possibility of re-contamination.

1.4.3 The closed circuit chilled and condenser water systems shall be flushed at least three times to remove all debris and dirt within the piping system before the water conditioning programme is commenced.

2. RELIABILITY AND AVAILABILITY

2.1 DOWN TIME

2.1.1 Response time on receiving complaint/non functional call and repair and/or replacement of faulty equipment and supply of necessary chemicals shall not exceed 36 hours.

2.2 EXTENDED SERVICE AND MAINTENANCE CONTRACT

2.2.1 Only water conditioning firms, well established in the RSA, regularly engaged in the installation and maintenance of these systems and who submit proof that they can (and will) honour Service Contract at an acceptable price, will be considered as an acceptable Subcontractor. [Refer PART C4.7]

2.2.2 The water conditioning system tenderer shall quantify and cost his proposed systems to prove that he has selected the optimum treatments for the installations.
2.3 DOCUMENTATION

2.3.1 At equipment submission stage, full sample Operating, Trouble Diagnosis, Service and Maintenance Manuals, together with training aids and procedures shall be submitted. (Refer Part C1.5 Section 18).

2.3.2 The water conditioning system Contractor shall submit full details of his proposed:

2.3.2.1 Fault detection and identification methods.
2.3.2.2 Fault correction methods.
2.3.2.3 Spare parts availability.
2.3.2.4 Documentation.
2.3.2.5 Operator's and Maintenance training.

3. TECHNICAL RESTRAINTS

3.1 The system shall be fully automatic. Chemicals shall be fed to circuits requiring continuous make-up by automatic proportional feeding devices.

3.2 Acid feeders when used shall be controlled by an electronic pH controller.

3.3 All necessary system cleaning, flushing and passivating must be completed before the system is started up and the control valves activated.

4. BUILDING RESTRAINTS

4.1 Chemicals used for the water conditioning shall have no detrimental effect on non-metallic materials, such as rubber, wood, plastic, etc used in the system.

4.2 Chemicals used for water conditioning and the methods to feed the chemicals shall comply with local by-laws. Chromate based water treatment programmes are not acceptable.

4.3 Chemical closing system trust be installed in/over a suitable size stainless steel pan to prevent damage to the surroundings in the event of a chemical spillage.

5. "MEASUREMENT" TO CONFIRM SYSTEM COMPLIANCE WITH SPECIFICATION

5.1 The system will only be taken over by the Employer after the following has been successfully completed by the water conditioning contractor:

5.1.1 Training of Employer's Operator and demonstration that the Operator is fully conversant with the system trouble diagnosis and corrective actions.

5.1.2 Demonstration that the system has been properly commissioned and that the system and its control is functioning properly for at least a 4 week period without any system downtime or malfunctioning.

5.1.3 The proper functioning of the entire supervisory water conditioning system shall be documented in a formal handover/test report written and signed by the system's responsible Engineer and accepted and countersigned by the air conditioning Subcontractor's Project Engineer.

5.1.4 The water conditioning system tenderer shall submit his pro-forma test/handover report at tendering stage.

5.1.5 No acceptance and/or preliminary handover of system will take place without acceptance by the Project Manager of formal handover report.
5.2 Water analysis and corrosion control tests shall be made at quarterly intervals to ensure proper control of corrosion, scale, algae, bacteria and slime and legionella pneumophila. Overall corrosion and pitting rates shall be measured by the suitable corrosion test coupons representing the metals in the circuit.

Report of service call, water analysis, corrosion tests, etc shall be submitted by water conditioning company, as part of their Service and Maintenance Contract.

Water conditioning contractor shall clean and disinfect the cooling towers and open section of condenser water system at least twice a year to remove sludge, slime and debris which may have accumulated during the previous operating period.

6. SCHEDULE - WATER SYSTEM PARAMETERS

**THIS IS AN EXISTING SYSTEM, IGNORE THE TABLE BELOW**

<table>
<thead>
<tr>
<th>Application</th>
<th>Refer Note</th>
<th>Unit</th>
<th>Tender</th>
<th>Offered</th>
<th>Tender</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Type of Water</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Type of System</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- Open or closed</td>
<td></td>
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<tr>
<td><strong>Material of Construction</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Galvanised or black steel</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>System Capacity</strong></td>
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<tr>
<td>- Volume of water</td>
<td></td>
<td>(m³)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum</td>
<td></td>
<td>(°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maximum</td>
<td></td>
<td>(°C)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**NOTES**

1. Estimated for tendering purposes only. To be confirmed at time of equipment submission.
1. FUNCTIONAL PERFORMANCE

1.1 OPERATING RANGE

Provision must be made for the damper to be closed and/or opened remotely if specified as such in the schedule. Under closed conditions, the leakage rate shall not be higher than is specified in the schedule.

2. RELIABILITY AND AVAILABILITY

The damper shall be so installed that replacement shall not take longer than 2 hours when executed by qualified building maintenance staff.

2.1 MEAN TIME BETWEEN FAILURES

The minimum acceptable service life is 15 years with 3,000 operating hours per annum and 50,000 control cycles per annum with a maximum deviation from this standard for 15% of the total number of items.

2.2 COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACT

Only suppliers/manufacturers who offer and submit proof that they can honour a 5 year comprehensive maintenance contract (renewable for another 5 years at the option of the building owner) will be considered as acceptable suppliers.[Refer PART C4.7]

2.3 DOCUMENTATION

Supplier of unit shall submit service, maintenance trouble shooting, installation and testing instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the equipment part of the O & M manual [Part C1.5 Section 18].

3. TECHNICAL RESTRAINTS

3.1 The damper blades shall be aerofoil shaped and manufactured from aluminium.

3.2 A mechanical stop shall be provided to prevent accidental damage to the damper blades as a result of maladjustment of controllers or actuators.

3.3 The damper casing shall be insulated to the same specification as for the ductwork of which it forms part of.
1. TECHNICAL RESTRAINTS

1.1 Filter frame shall be suitable for standard commercial range of filter elements and filter media available. Filter size shall be preferably 595x595mm or 295x295mm.

1.2 Air filter gauge - type Magnahelic or equal approved - shall be provided for each filter bank.

1.3 Adequate access shall be provided for changing filters.

1.4 The filter elements and filter frame shall be fully corrosion protected and be weather and water proof.

1.5 The filter shall be so constructed that the pleated material contained within the frame will remain configured for maximum dust holding and ease of cleaning. Should the function of the filter be in any way permanently impaired, then it shall be replaced by the subcontractor.

1.6 Construction of filter frame and method of holding down filter elements shall ensure no passage of unfiltered air through filter bank. Holding frames shall be fitted with gaskets and clips.

2. PRIMARY FILTERS

2.1 Filter media shall be washable type and shall be durable for at least 12 washes without losing its efficacy, shape and form.

2.2 Framework shall be aluzinc roll formed channel section double return bend to eliminate sharp edges and increase structural strength.

2.3 Filter media shall be supported with spot welded galvanised wire mesh 25mm x 25mm on both sides of the media.

2.4 At an approach velocity of 2.5m/s, initial resistance shall not exceed 60Pa and final resistance limited to 250Pa.

2.5 Average Arrestance shall be 90% to EN779-2012 and ASHRAE Dust spot efficiency <30%.

3. SECONDARY FILTERS

3.1 Filter media shall be extended surface cassette type with mini pleated microglass paper media and hot melt separators.

3.2 Filter media shall be housed in a polypropylene injection moulded frame.

3.3 Surface area per 595x595mm filter media shall be 18m2 or greater.

3.4 At an approach velocity of 2.5m/s, initial resistance shall not exceed 80Pa and final resistance limited to 600Pa. Burst pressure shall be 2000Pa.

4. APPLICATION GUIDELINES

Refer Table 1 for cross-references and application guidelines.
# TABLE 1 CROSS-REFERENCE AND APPLICATION GUIDELINES

<table>
<thead>
<tr>
<th>ISO Rating</th>
<th>Standard 52.2 MERV</th>
<th>Intended Standard 52.1 Value</th>
<th>Arrestance Value</th>
<th>Example range of Contaminants Controlled</th>
<th>Example Applications</th>
<th>Sample Air Cleaner Type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HEPA Filters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H14</td>
<td>MERV 20</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>H13</td>
<td>MERV 19</td>
<td>N/A</td>
<td>0.12 to 0.5 µm particles: virus (unattached), carbon dust, sea salt, radon progeny, combustion smoke</td>
<td></td>
<td></td>
<td>SULPA &gt;99.99% 0.1 to 0.2 µm IEST type F (ceiling panel)</td>
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<tr>
<td>H12</td>
<td>MERV 18</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>H11</td>
<td>MERV 17</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>E-1 Range</strong></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>H10</td>
<td>MERV 16</td>
<td></td>
<td>&gt;99%</td>
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<tr>
<td>F9</td>
<td>MERV 15</td>
<td></td>
<td>&gt;99%</td>
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<tr>
<td>F8</td>
<td>MERV 14</td>
<td></td>
<td>&gt;98%</td>
<td></td>
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</tr>
<tr>
<td>F7</td>
<td>MERV 13</td>
<td>Intended to replace 70 to 98% dust-spot efficiency filters</td>
<td>&gt;97%</td>
<td>0.3 to 1.0 µm size range: bacteria, smoke (ETS), paint pigments, face powder, some virus, droplet nuclei, insecticide dusts, soldering fumes</td>
<td>Day Surgery, general surgery, hospital general ventilation, turbo equipment compressors, welding/soldering air cleaners, prefilters to HEPA, LEED for existing (EB) and new (NC) commercial buildings, smoking lounges</td>
<td>Box-style wet-laid lofted fiberglass, box-style synthetic media, minipleated synthetic or fiberglass paper, depths from 100 to 300 mm, Pocket filters of fiberglass or synthetic media 300 to 900 mm</td>
</tr>
<tr>
<td><strong>E-2 Range</strong></td>
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<tr>
<td>F6</td>
<td>MERV 12</td>
<td></td>
<td>&gt;97%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MERV 11</td>
<td></td>
<td>&gt;95%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| | MERV 10 | Intended to replace 50 to 80% dust-spot efficiency filters | >95% | 1.0 to 3.0 µm size range: milled flour, lead dust, combustion soot, 
Legionella, coal dust, some bacteria, process grinding dust | Food processing facilities, air separation plants, commercial buildings, better residential, industrial air cleaning, prefiltration to higher-efficiency filters, schools, gymnasi | Box-style wet-laid or lofted fiberglass, box-style synthetic media, minipleated synthetic or fiberglass paper, depths from 50 to 300 mm. Pocket filters either rigid or flexible in synthetic or fiberglass, depths from 300 to 900 mm |
| F5 | MERV 9 | | >90% | | | |
| **E-3 Range** | | | | | | |
## ISO Rating

<table>
<thead>
<tr>
<th>ISO Rating</th>
<th>Standard S52.2 MERV</th>
<th>Intended Standard S52.1 Value</th>
<th>Arrestance Value</th>
<th>Example Range of Contaminants Controlled</th>
<th>Example Applications</th>
<th>Sample Air Cleaner Type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G4</td>
<td>MERV 8</td>
<td></td>
<td>&gt;90%</td>
<td>3.0 to 10 µm size range: pollens, earth-origin dust, mold spores, cement dust, powdered milk, snuff, hair spray mist</td>
<td>General HVAC filtration, industrial equipment filtration, commercial property schools, prefilter to high-efficiency filters, paint booth intakes, electrical/phone equipment protection</td>
<td>Wide range of pleated media, ring panels, cubes, pockets in synthetic or fiberglass, disposable panels, depths from 25 to 600 mm</td>
</tr>
<tr>
<td>G3</td>
<td>MERV 6</td>
<td>Intended to replace 20 to 60% dust-spot efficiency filters</td>
<td>&gt;90% &gt;85%</td>
<td>Example Applications</td>
<td>Sample Air Cleaner Type(s)</td>
<td></td>
</tr>
<tr>
<td>G2</td>
<td>MERV 4 &lt;20%</td>
<td>&gt;70%</td>
<td></td>
<td>Arrestance method</td>
<td>Protection from blowing large particle dirt and debris, industrial environment ventilation air</td>
<td>Inertial separators</td>
</tr>
<tr>
<td>G1</td>
<td>MERV 1 &lt;20%</td>
<td>&lt;65%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NOTES

1. Refer layout drawings for schedules.
2. All figures given are for an altitude as specified in Part C3.1.
3. Resistance figures are for tendering purposes only and are to be confirmed at time of equipment submission.
1. GENERAL

1.1 The system shall be an air cooled, split type multi-system air conditioner with one or more interconnected outdoor units serving multiple indoor units through a common refrigerant network.

1.2 Where specified as a Heat Pump system in the schedule the outdoor and all the indoor units shall operate either in cooling or heating mode according to the selected mode on the master controller.

1.3 Where specified as a Heat Recovery system in the schedule, the outdoor unit and all the indoor units shall cool or heat independently according to individual controller settings and room conditions.

1.4 VRV REFRIGERANT PIPE CALCULATIONS

The detailed calculation and schematic layout of each of the VRV pipe systems must be provided with the tender document for the specific system selected with accompanying technical information from the supplier.

1.5 EQUIPMENT SELECTED PERFORMANCE CALCULATIONS

The detailed calculation of the cooling, heating, total and sensible capacities at altitude of the equipment must be provided with the tender document.

1.6 TECHNICAL INFORMATION

Technical tables of the equipment must be provided with the tender.

2. OPERATING RESTRAINTS

2.1 OPERATING RANGE

2.1.1 The indoor unit fan duty shall not decrease more than 10% when filter dirty. The operating point shall be the stable part of the curve.

2.1.2 Unit shall operate continuously in cooling or heating without damage or malfunction for the following range of conditions at local altitude.

| Indoor Unit Entering Air Dry Bulb Temperature | : | 18°C – 28°C |
| Indoor Unit Entering Air Wet Bulb Temperature | : | 13°C – 20°C |
| Outdoor Unit Entering Air Dry Bulb Temperature | : | -5°C – 40°C |

2.1.3 A “low ambient” condensing control shall be incorporated in the outdoor unit.

2.1.4 Refrigerant piping shall be capable of a maximum length of 150m with a 50m level difference where the outdoor unit is above the indoor unit and 40m where the outdoor is below the indoor unit.

2.1.5 The unit supplier will be responsible for the design of the refrigeration piping so as to guarantee the operation of the system under the specified conditions.

2.2 SAFETY

2.2.1 Fan motor shall be non-over loading at any operating point on the performance curve.

2.2.2 Both indoor and outdoor units shall be fully protected and shall fail safe.
2.2.3 Minimum safety protection, caused by possible external abnormal conditions shall be provided for the following, and require manual or automatic reset after fault occurrence.

2.2.3.1 High discharge temperature
2.2.3.2 High discharge pressure
2.2.3.3 Low suction pressure/anti-freeze protection
2.2.3.4 Low oil pressure/oil temperature
2.2.3.5 Thermal overload protection
2.2.3.6 Current overload protection on compressor
2.2.3.7 Re-starting time delay for compressor
2.2.3.8 Auto re-start on power supply interruption
2.2.3.9 Inverter Overload protector
2.2.3.10 Low and high voltage and phase failure protection.

2.2.4 A safety valve or rupture disc shall be incorporated in the piping system.

2.2.5 Rupture discs shall have a specified and certified bursting pressure at a specified temperature and shall be marked on the disc.

2.2.6 The system shall comply with the Safety Code for Refrigerant Piping ASA B31.35 – 1962 with the local requirements of ASME, with Occupational Health and Safety Act, as amended, and with local authorities by-laws. Refer Part C1.5 Section 5.

3. BUILDING RESTRAINTS

3.1 Units shall be installed in accordance with manufacturer’s recommendations and shall be capable of being fitted into the spaces indicated on the engineering drawings.

3.2 The unit shall not drum, vibrate or leak under any operating conditions.

3.3 Noise level in the conditioned space through the operation of the unit at any operation point shall not exceed the specified noise level with an 8db room attenuation factor in each octave band.

3.4 All penetrations through building structures shall be sealed against ingress of water and air.

3.5 All piping/conduits/wiring/supports shall be neatly and securely fixed to the building structure. Method of fixing shall be submitted to client/representative prior to installation.

3.6 The unit shall be suitable for mounting as indicated on the drawings.

3.7 Refrigerant piping between indoor and outdoor units shall be supported along its entire length by a galvanized perforated cable tray of sufficient size to allow pipework to be neatly laid out and insulated. The cable tray to be supported clear of fixing surface by galvanized brackets allowing air space between cable tray and mounting surface.

3.8 Where piping and insulation is exposed to damage or located externally to the building, a galvanized sheet metal cover having a minimum thickness of 0.8mm shall be neatly formed and secured to the cable tray brackets. Joints to be lapped by a minimum of 30mm and to have minimum clearance of 10mm over insulation.

3.9 Position and method of fixing of the indoor/outdoor/and remote sensor with interconnecting cable shall be confirmed with the client representative.

3.10 It shall be possible to install the control facilities within a suitable draw box recessed into the wall/partition, with the control cable reticulated within an enclosed conduit.
4. **RELIABILITY AND AVAILABILITY**

4.1 **MEAN TIME BETWEEN FAILURES**

4.1.1 All components, casings and refrigeration network shall be designed for a service life of 15 years for local conditions based on a 12 hour daily operation.

4.1.2 All components which may come in contact with water (rain, condensate, sweating of compressor, etc.) shall be protected against corrosion in order to obtain the desired service life.

4.2 **COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACTS**

4.2.1 Only suppliers who offer, and submit proof that they can honour, a 5 year (renewable to 10 years) Comprehensive Guarantee Contract will be considered as acceptable suppliers.

4.3 **DOCUMENTATION**

4.3.1 Supplier of the unit shall submit service, maintenance, trouble shooting, installation and testing instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the Equipment Part of the O&M Manual.

4.3.2 The supplier shall submit the result of the propriety design programme of the refrigeration network design, complete with the update refrigeration network shop drawing based on the engineers layout drawing.

4.3.3 The supplier shall also submit builders work requirements should these deviate from what is indicated on the engineers layout drawings.

4.3.4 The suppliers shall submit/confirm electrical requirements as soon as appointed.

4.3.5 At project completion, supplier is to provide written confirmation detailing the HVAC system - equipment, quantity of equipment supplied, type and mass of all refrigerants and gasses used.

5. **MEASUREMENT TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION**

5.1 The supplier of the unit shall submit with his tender certified performance tests of capacity and power consumption at either ISO conditions or local conditions by the SABS or a similar organisation.

5.2 Performance must be based on the actual mounting details, pipe lengths, indoor and outdoor air conditions and location where installed.

5.3 Performance testing of each outdoor unit shall be done in a certified “on line” test facility. The minimum tests shall include running amps compressor, entering and leaving temperatures, a leak test, the heater amperage, all controls for function and calibration of thermostats. All results shall be properly recorded against the serial number of the unit and signed off by the responsible person quality.

6. **TECHNICAL RESTRAINTS – OUTDOOR UNIT**

6.1 Compressors shall be hermetic scroll type and be equipped with an inverter controller, capable of changing the rotating speed to follow variations in cooling and heating load. The outdoor unit shall be compatible with the full selection of indoor unit options listed in the schedule on a single system.

6.2 The unit casing shall be corrosion proofed mild steel with a baked enamel or powder coated finish to a finish acceptable to the architect.

6.3 The outdoor units shall be modular in design and suitable for side by side installation.
6.4 The heat exchanger shall be manufactured from copper tubes and Aluminium fins with anticorrosion treatment.

6.5 An oil recovery system shall ensure stable operation with long refrigerant piping. The outdoor unit shall incorporate factory fitted oil separators, liquid receiver and filler drier systems.

6.6 The outdoor coil shall be “hail proof” if specified as such in the schedule. Coil and refrigerant shall be protected from freezing in ambient temperatures down to -10°C.

6.7 Where specified in the schedule, more than one scroll compressor hall be provided per outdoor unit. The outdoor unit shall continue to operate with a fault condition on one of the compressors. Controls of the outdoor unit shall equalise running hours on each compressor.

6.8 The outdoor unit shall have the following indicators.

6.8.1 Oil pressure/Oil temperature
6.8.2 Evaporation pressure
6.8.3 Condensing pressuring
6.8.4 Voltage
6.8.5 Ammeter.

6.9 FANS

6.9.1 Fans shall be plate mounted axial or propeller type and shall be statically and dynamically balanced. Fan motors and bearings shall be protected against ingress of water.

6.9.2 Bearings shall be permanently lubricated.

6.9.3 Fans shall be variable speed.

7. TECHNICAL RESTRAINTS – REFRIGERANT PIPING SYSTEM

7.1 REFRIGERANT

7.1.1 Refrigerant pipe sizing is the responsibility of the unit supplier and calculations/schematics shall be submitted for approval.

7.1.2 The necessary traps should be installed in the refrigerant lines to ensure oil return for applications where the outdoor unit is installed higher than indoor units.

7.1.3 Refrigerant piping accessories and connections shall be selected to ensure no leakage from refrigerant piping system during its operational life.

7.1.4 The refrigerant accessories shall be so connected and installed into the refrigerant piping system that either a sub-component replacement or total removal and reinstallation of the accessory shall not take longer than 2 hours by qualified refrigeration mechanics.

7.1.5 The entire refrigerant system shall be pressured tested at a pressure of 3,000kPa with nitrogen for 24 hours without any loss of pressure.

7.1.6 The entire system shall be evacuated and proved to be free of moisture. The minimum vacuum for testing shall be 4mm Hg for 12 hours without any change in vacuum.

7.1.7 The refrigerant piping system shall be charged with refrigerant and oil in accordance with the supplier’s recommendation procedures.

7.1.8 Refrigerant pipework shall be constructed in copper tubing to the supplier’s recommended material and construction specifications. (Maksal or equal approved).
7.1.9 All fittings and accessories shall be provided in accordance with the suppliers recommended specification and installation procedure. Fitting and accessories shall comply with the following minimum requirements.

7.1.10 Nitrogen flushing shall be done on field pipe installations during welding/brazing.

7.2 SHUT OFF VALVES

7.2.1 Liquid and gas shut off valves shall be provided at each indoor, outdoor unit and accessories. Refrigerant stop valves generally shall be of the back seating key operated, sealed cap type. Valves which must be opened and closed in regular operation shall have hand wheels and shall be of the packless type.

7.2.2 Shut off valves shall be installed to each branch valve as shown on the drawings or at least per floor level to allow phased installation and/or future alterations to occur without affecting the balance of the system in operation whilst in construction.

7.3 REFRIGERANT STRAINERS

7.3.1 Refrigerant strainers shall be of the angle type, cleanable without disturbing pipe connections. 40 mm N.B. strainers and smaller shall have brass bodies and solder joint connections and 50 mm N.B. strainers and larger shall have brass or rust proofed steel or iron bodies and flanged connections. Connections shall be flanged and bolted.

7.3.2 Screens shall be bronze metal with perforations not larger than 0.25 mm for liquid lines and 0.5 mm for gas lines. The free area of each screen shall not be less than 5 times the area of the strainer inlet pipe.

7.4 CHARGING VALVES

7.4.1 Charging valves shall be located into the liquid line between the receiver shut-off valve and expansion valve.

7.4.2 Branch lines per floor at each shut off valve and at the end of line shall incorporate charging valves to allow phased installation to occur and/or alterations to the system without major shutdowns to the system for purging and charging the branch lines as they are installed or modified.

7.5 GAUGE VALVES

7.5.1 External gauge connections to be provided at inlet and outlet of condenser, evaporator coil and compressor for evaluation of system pressures at commissioning and for normal maintenance inspections.

7.6 GAUGES

7.6.1 All gauges shall be connected to the refrigerant and piping system, through isolating shut-off valves.

7.7 VIBRATION ISOLATORS: FLEXIBLE CONNECTORS

7.7.1 Suction and discharge lines from the compressor shall be fitted with flexible connectors of the bronze braided hose type, having sweat-ends, to fit over copper tubing having the same size as the line in which they are installed.

7.8 EXPANSION VALVES

7.8.1 Expansion valves shall have an automatic re-calibration facility.

7.8.2 In field assembled systems, each evaporator circuit shall be provided with an expansion valve of the gas charged type. Valves shall have external equalizer connections, external superheat adjustments with seal caps. Valves shall be permanently sealed diaphragm type where no soldering is required. (Clip on/off diaphragm type). Valves shall require not more than 3 degrees C superheat change to move from fully open to fully closed. Superheat setting shall be 6 degrees C at full load.
7.8.3 Piping shall be stored and handled on site to prevent dirt from entering piping system. Open ends shall be plugged. Piping shall be flushed with Nitrogen during brazing/welding.

7.8.4 Piping shall be installed so as to allow for expansion and contraction. Suction and discharge lines shall be installed so that the first point of support is 6 pipe diameters in each of three directions from unit.

7.8.5 System vibration isolation shall be in accordance with Sound and vibration Control. (Refer Part IV Section 5).

7.8.6 Thermal insulation of suction line shall be in accordance with insulation. (Refer Part C3.2 Section 4). Insulation shall be UV resistant and rodent proof. Insulation exposed to outside weather shall be finished off with UV resistant plastic tape.

8. TECHNICAL RESTRAINTS – INDOOR UNIT

8.1 GENERAL

8.1.1 The type of indoor unit is specified in the schedule.

8.1.2 An electronic control valve shall regulate the refrigerant flow to the indoor unit.

8.1.3 Each indoor unit/group of units shall have a unique address in case of individual/group control and in case of a central controller the address shall be set from the central controller.

8.2 INDOOR UNIT

8.2.1 Cabinet

8.2.1.1 Deflectors shall be available on exposed indoor units to deflect the airflow in any direction or to concentrate the flow of air as required.

8.2.1.2 Service panels shall be provided to give access to compressor, fans, controls and electrical connections. No special tools should be required to remove these “easily removable” panels.

8.2.1.3 Cabinets shall be constructed from fully galvanised sheet metal powder coated to an approved colour.

8.2.2 Fans

8.2.2.1 Fan motors and bearings shall be protected from ingress of water.

8.2.2.2 All fan bearings shall be of the permanently lubricated type.

8.2.2.3 Fans shall be double inlet centrifugal fans statically and dynamically balance.

8.2.3 Drains

Drainage of condensate from the units shall be collected by the following means.

8.2.3.1 A pan of sufficient size to catch all drippage which may emanate from the unit.

8.2.3.2 Drainage via gravity feed from this pan to a suitable connection; or

8.2.3.3 Booster pump assisted drainage where indicated on the relevant drawings or in the accompanying schedule. The pump shall be capable of pumping to a height of minimum 500mm.

8.2.3.4 The drain pan shall be fabricated from galvanised sheet steel and be painted internally and insulated to prevent condensation.

8.2.3.5 Drain piping shall be fixed and routed to the nearest suitable drain point to ensure positive drainage. Drain piping shall be resistant or protected against weather elements or people traffic.
8.2.4 Electrical

8.2.4.1 All electrically powered elements within the unit shall have an adequate resistance to earth, with due regard to the possible condensation of moisture and comply with statutory requirements.

8.2.4.2 Interconnecting wiring from the outdoor unit to the indoor unit shall be via conduits or suitable special cable.

8.2.4.3 Power supply from the local isolator shall be protected against the elements by means of conduit or suitable cable.

8.2.5 Filter

8.2.5.1 Filters shall be of the fire resistant, dry media type, with an efficiency < 20% by the ASHRAE test. Filters shall be replaceable without special tools.

8.2.6 Coil

8.2.6.1 The indoor coil shall be aluminium fins, mechanically bonded to seamless copper tubes. The fin spacing shall not be less than 2mm. The coil face velocity shall be such that no 'water carry over' will take place during any operation condition.

8.2.6.2 Aluminium fins shall be coated with a anticorrosion coating.

8.2.7 Control

8.2.7.1 Temperature control of indoor units shall be PID control. Set points shall be adjustable within a range between 19°C and 24°C. Controller shall select cooling/heating/ventilation mode on the unit and control the refrigerant supply to the unit within an electronic control device. Controllers shall have self-diagnostic capabilities and shall memorise the last malfunction.

8.2.7.2 Where a wireless remote controller is provided a manual override function shall be provided on the indoor unit.

8.2.7.3 A LCD controller shall be capable of controlling units individually or in groups. Fan speed and air distribution shall be controlled individually on indoor units in individual or group control arrangement. Controllers shall be clearly marked and easy to operate.

8.2.7.4 Under no circumstances shall any error on any indoor unit prevent the complete system from operating. The supplier shall ensure that the controls be designed to maintain system operation at all times. Should any additional equipment be required to perform this action, this shall be indicated clearly and should be quantified accordingly.

8.2.8 Central Controller

8.2.8.1 A Central controller shall be supplied where specified in the schedule.

8.2.8.2 The central controller shall control up to 50 indoor units with the following functions:

a) Temperature setting for each zone or group, or indoor unit.
b) On/off as a zone or individual unit
c) Indication of operating condition
d) Select one of 10 operation modes for each zone.

8.2.8.3 The controller shall have wide screen liquid crystal display and can be wired by a non-polar 2 wire 1.5mm² shielded transmission cable to a distance of 1km away from the indoor unit.
8.2.9 Central On/Off Controller

A central on/off controller shall be provided where specified in the schedule and shall control up to 16 zones with the following functions.

8.2.9.1 On/off as a zone or individual unit
8.2.9.2 Indication of operation condition of each group.
8.2.9.3 Select one of 4 operation modes.

8.2.10 Central Timer Control

A Central timer control shall be provided where specified in the schedule and shall control up to 128 units with the following functions:

8.2.10.1 Twice a day on/off for normal days and holidays.
8.2.10.2 Schedules when used in combination with a central controller.

8.2.11 Intelligent Touch or PC Controller

A basic building management system with either a touch control or a PC interface.
### Schedule – Outdoor – Heat Recovery System

<table>
<thead>
<tr>
<th>Identification Outdoor Unit</th>
<th>Units</th>
<th>Notes</th>
<th>Tender</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification No.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Drawing No. Reference</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Type of system (Heat Pump/Heat Recovery)</td>
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<td>Heat Recovery</td>
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<td></td>
</tr>
<tr>
<td>Refrigerant Type</td>
<td>kg</td>
<td></td>
<td>Supplier</td>
<td></td>
</tr>
<tr>
<td>Refrigerant Mass</td>
<td>m</td>
<td></td>
<td>Supplier</td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td>1600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No off compressors per unit</td>
<td></td>
<td>Min 2</td>
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<td></td>
</tr>
<tr>
<td>Power supply (V/ø/Hz)</td>
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<td>400/3/50</td>
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<tr>
<td>Maximum Air Flow</td>
<td>l/s</td>
<td></td>
<td>Supplier</td>
<td></td>
</tr>
<tr>
<td>External Static Pressure</td>
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<td>Pa</td>
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<td></td>
</tr>
<tr>
<td>Noise Level @ 3m</td>
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<td>NC 50</td>
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</table>

#### Cooling Mode

- Total Capacity (kW) 1, Refer to Schedule
- Sensible Capacity (kW) 1, Refer to Schedule
- Estimated total capacity at standard conditions (kW) 1, Refer to Schedule
- Control Range (%) 20%
- Entering air condition (db/wb) °C Refer to Schedule
- Power consumption @ design conditions (kW) 1, Supplier

#### Heating Mode

- Sensible Capacity (kW) Refer to Schedule
- Estimated sensible capacity at standard conditions (kW) 1, Refer to Schedule
- Entering air condition (db/wb) °C
- Control range (%) 20%
- Power consumption @ Design conditions (kW) 1 Supplier

#### Optional Extras

- Copper/Copper coils Yes/No
- Special coated condensers Yes/No
- Hail protection Yes/No

#### Notes

1. Estimated for tender purposes only. To be confirmed by equipment submission
2. Standard conditions:
   - Cooling Mode: Sea Level 35°C DB 24°C Wb
   - Heating Mode: Sea Level 7°C DB/6°C Wb
3. The following Hydro Fluorocarbon (HFC) type refrigerants will be accepted as they have a zero Ozone Depletion Potential (ODP) – R134a, R407c, R410a, R290, R600, R1270 & Ammonia
### SCHEDULE – INDOOR UNIT

<table>
<thead>
<tr>
<th>Identification Outdoor Unit</th>
<th>Units</th>
<th>Notes</th>
<th>Tender</th>
<th>Offered</th>
<th>Tender</th>
<th>Offered</th>
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<tr>
<td>Drawing No. Reference</td>
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</tr>
<tr>
<td>No. off</td>
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<td>Indoor unit – Type</td>
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<td>Type of central controller</td>
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<tr>
<td>Group control Identification</td>
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<td>230/1/50</td>
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<td>Maximum air flow</td>
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<td>Leaving condition (db/wb)</td>
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### Cooling Mode

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<td>Refer to Schedule</td>
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<td>Sensible capacity</td>
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<td></td>
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<td>Power consumption</td>
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### Optional Extras

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<tr>
<td>Fresh air inlet opening</td>
<td></td>
<td>Yes</td>
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<td></td>
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<tr>
<td>Automatic air distribution louvres</td>
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<td></td>
<td></td>
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<tr>
<td>Room controllers type</td>
<td>5</td>
<td>WC</td>
<td></td>
<td></td>
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</tbody>
</table>

### NOTES

1. Based on the following entering conditions at sea level
   - Summer: 27°C/D/71/19
   - Winter: 20°C/W/20
   - Indoor unit (ºCdb/ºCwb)
2. Indoor unit types
   - 1W CAS- 1 Way blow cassette
   - 2W CAS- 2 Way blow cassette
   - 4W CAS- 4 Way blow cassette
   - Corner CAS - Corner type blow cassette
   - MS HA - Medium static hide away
   - HS HA - High static hide away
   - UC - Under ceiling
   - WM - Wall mounted type
   - FS - Floor standing type
3. Estimated for tendering purposes only.
4. Central Control options
   - cc Central Controller
   - COOC Central on/off controller
   - CTC Central Timer Controller
   - ITC Intelligent touch controller
   - IPCC intelligent PC controller
5. Room Controller Type
   - WC Wired Controller
   - RC Remote Controller

To be confirmed at time of equipment submission.
### 11. SCHEDULE OF VRF SYSTEMS

#### 11.1 Basement 1 Indoor Units

<table>
<thead>
<tr>
<th>Identification</th>
<th>Drawing reference</th>
<th>Unit type</th>
<th>Total Cooling Capacity (kW)</th>
<th>Sensible Cooling (kW)</th>
<th>Heating Capacity (kW)</th>
<th>Supply Air Flow (L/s)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRFHU-01</td>
<td>4GF</td>
<td>Hideaway</td>
<td>3.5</td>
<td>3.2</td>
<td>4.1</td>
<td>185</td>
<td>13</td>
</tr>
<tr>
<td>VRFHU-04</td>
<td>4GF</td>
<td>Hideaway</td>
<td>6.8</td>
<td>6.3</td>
<td>8</td>
<td>190</td>
<td>1</td>
</tr>
<tr>
<td>VRFHU-05</td>
<td>4GF</td>
<td>Hideaway</td>
<td>8.5</td>
<td>7.9</td>
<td>10</td>
<td>475</td>
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<td>VRFHU-06</td>
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#### 11.2 Ground Floor Indoor Units

<table>
<thead>
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<th>Drawing reference</th>
<th>Unit type</th>
<th>Total Cooling Capacity (kW)</th>
<th>Sensible Cooling (kW)</th>
<th>Heating Capacity (kW)</th>
<th>Supply Air Flow (L/s)</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>VRFCU-01</td>
<td>4GF</td>
<td>4W Cassette</td>
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<td>VRFHU-03</td>
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<td>4.8</td>
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<td>VRFHU-04</td>
<td>4GF</td>
<td>Hideaway</td>
<td>6.8</td>
<td>6.3</td>
<td>8</td>
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</tr>
<tr>
<td>VRFHU-05</td>
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<td>10</td>
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</tr>
<tr>
<td>VRFHU-06</td>
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<td>12.4</td>
<td>16</td>
<td>710</td>
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</tr>
<tr>
<td>VRFHU-07</td>
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<td>13.9</td>
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#### 11.3 First Floor Indoor Units

<table>
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<th>Identification</th>
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<th>Unit type</th>
<th>Total Cooling Capacity (kW)</th>
<th>Sensible Cooling (kW)</th>
<th>Heating Capacity (kW)</th>
<th>Supply Air Flow (L/s)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRFCU-01</td>
<td>401</td>
<td>4W Cassette</td>
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<td>VRFCU-02</td>
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<td>VRFCU-03</td>
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<td>VRFHU-01</td>
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<td>VRFHU-02</td>
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<td>4.3</td>
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#### 11.4 Second Floor Indoor Units

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<th>Heating Capacity (kW)</th>
<th>Supply Air Flow (L/s)</th>
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<td>4W Cassette</td>
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<td>VRFHU-01</td>
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<td>3.2</td>
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<td>185</td>
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<td>VRFHU-03</td>
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</table>
1. **GENERAL**

1.1 Detailed schedules for terminals are shown on the layout drawings.

1.2 All figures given are for an altitude as specified in Part C3.1.

1.3 The throw is based on the following:

   1.3.1 **Supply air grilles**
   
   Minimum throw : end of throw velocity = 0.65 m / s
   
   Maximum throw : end of throw velocity = 0.40 m / s

   1.3.2 **Square or rectangular ceiling diffusers**
   
   Minimum throw : room air velocity = 0.25 m / s
   
   Maximum throw : room air velocity = 0.10 m / s

   1.3.3 **Linear ceiling diffusers**
   
   Minimum throw : room air velocity = 0.25 m / s
   
   Maximum throw : room air velocity = 0.10 m / s

1.4 Unless otherwise specified, terminals shall be powder coated to an approved colour.

2. **SUPPLY AIR GRILLES (SIDE WALL OUTLETS) (IDENTIFICATION “SAG”)**

Supply air grilles shall be of the double deflection type with adjustable horizontal vanes in front and adjustable vertical vanes in the rear. The vane spacing shall be approximately 20 mm.

3. **RETURN AIR GRILLES, EXTRACT GRILLES OR TRANSFER GRILLES (IDENTIFICATION “RAG”)**

3.1 Return-, extract- or transfer air grilles shall be of the single deflection type with fixed horizontal vanes. The vane spacing shall be approximately 20 mm.

3.2 Unless identified RAG45, indicating that the vanes are set under a 45 degree angle, the vane-setting shall be zero degrees.

3.3 Identification RAGe indicates that the grille is of the egg crate type.

4. **CEILING DIFFUSERS (IDENTIFICATION "SAD" FOR SUPPLY AIR AND "RAD" FOR RETURN AIR)**

4.1 Square or rectangular ceiling diffusers shall have a removable core.

4.2 The subcontractor shall ensure that the ceiling construction will be able to carry the weight of the diffuser.

4.3 Unless identified with suffix 1, 2 or 3, for either 1-way blow, 2-way blow or 3-way blow, i.e. SAD3, the ceiling diffuser shall be of the 4-way blow type.

5. **DOOR GRILLES (IDENTIFICATION "DG")**

Door grilles shall be of the "NO SIGHT" type.

6. **INTAKE-OR EXHAUST WEATHER LOUVRES (IDENTIFICATION "WL")**

6.1 The weather louvre shall be complete with a mounting frame suitable for building in by the builder.

6.2 The weather louvre shall be vermin-proofed.
1. FUNCTIONAL PERFORMANCE

1.1 CAPACITY CONTROL

The volume supplied by the terminal and the switching of the electric heater shall be controlled by a remote electronic modulating thermostat. It shall be possible to control multiple terminals from one thermostat. - Refer Terminal Control Arrangement Drawing.

2. RELIABILITY AND AVAILABILITY

2.1 DOWNTIME

The air terminal shall be so constructed and installed that removal and reinstallation shall not take longer than 1 hour.

2.2 MEAN TIME BETWEEN FAILURE

The minimum acceptable service life is 15 years with 3 000 operating hours per annum and 4 000 control cycles per annum, with a maximum deviation from this standard for 15% of the total number of items.

2.3 COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACTS

Only Suppliers who offer, and submit proof that they can honour, a 5 year (renewable to 10 years) Comprehensive Guarantee Contract will be considered as acceptable suppliers. (Refer PART C4.7).

2.4 DOCUMENTATION

Supplier of terminals shall submit service, maintenance, trouble shooting, installation and testing instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the Equipment Part of the O & M Manual Part C1.5 Section 18.

3. TECHNICAL RESTRAINTS

3.1 The terminal shall be complete with a plenum box with side entry spigot. The plenum box shall contain the heater and the damper motor. The damper motor shall be shielded from the heater.

3.2 The air terminal shall be suitable for attaching on a standard flexible connection.

3.3 The air terminal shall be complete with factory calibrated balancing device to adjust the specified air volumes under "full-open" conditions.

3.4 The discharge pattern shall be constant under all flow conditions, i.e. there shall be no "dumping of air" under minimum flow.

3.5 The diffuser and mounting plate shall be powder coated to an approved colour.

3.6 The air terminals shall be of the high induction variable volume swirl diffusers.

3.7 The electric heater shall be complete with:

3.7.1 Auto reset thermal cut-out device set at 65°C.

3.7.2 Manual reset thermal cut-out device set between 80 - 100°C with reset button, labelled and operable without removing any terminal box cover.
3.8 Elements shall have an adequate resistance to earth, with due regard to the possible condensation of moisture during the cooling cycle.

3.9 One only, 3m long fixed electrical connection terminating in a 16A 57° facetted earth 3 pin plug top shall be provided for each terminal.

4. **BUILDING - LOCATION - AUTHORITIES RESTRAINTS ON EQUIPMENT**

4.1 The Subcontractor shall ensure that the ceiling construction will be able to take the operating weight of the terminal.

4.2 Noise level in the conditioned space through the operation of the unit at any operation point shall not exceed the noise levels specified for the particular room in Clause C3.1.

5. **"MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION**

5.1 Subcontractor shall supply the necessary field testing instruments (air flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 10% for Terminal Acceptance Testing.

5.2 Performance testing of the terminal shall be done in a certified laboratory with formal testing and certification procedures, and results of test certified by a responsible person/Professional Engineer.

5.3 The various tests as required by the Quality Management System shall be demonstrated and be accessible to the Engineer at all times for monitoring.

6. **SCHEDULE**

6.1 Refer layout drawings for schedules.

6.2 All figures given are for an altitude as specified in Part C3.1.

6.3 The throw (min. to max.) is based on an end of throw velocity of 0.50 - 0.25 m/s respectively under maximum flow conditions.

6.4 The nominal size is the "neck" size of the diffuser.
1. **FUNCTIONAL PERFORMANCE**

1.1 This specification shall be read in conjunction with the drawings.

1.2 Except where otherwise indicated sound attenuators shall be the product of a manufacturer regularly engaged in the production thereof such as Luft, Donkin, Trox, AMS or other approved.

1.3 Published catalogue data or a certified laboratory test report showing sound attenuation characteristics of each sound attenuator shall be submitted for approval.

1.4 In the case of corrosive airflow applications, the complete sound attenuator shall be compatible with the application.

1.5 The sound absorbing material shall not impart any odour to the discharge air, delaminate or be loosened by the air stream under regular operating conditions. The material shall be vermin-proof, fire retardant and rot resistant.

2. **RELIABILITY AND AVAILABILITY**

2.1 **DOWN TIME**

The attenuator shall be installed in such a way that the downtime of the duct system does not exceed 1 hour when either service/repair or removal and re-installation is required [Refer PART C4.7].

2.2 **DOCUMENTATION**

An attenuator requiring service, maintenance, trouble shooting, periodic replacement, etc., shall be documented in accordance with the equipment part of the 0 & M Manual. [Refer Part C1.5 Section 18].

3. **TECHNICAL RESTRAINTS ON SYSTEM**

3.1 Sound attenuators shall be constructed to the minimum dimensions indicated on the drawings.

3.2 Attenuator casings shall be constructed from pre-galvanised steel sheet and shall be capable of withstanding pressures up to 2500 Pa.

3.3 Rectangular inline attenuators shall be constructed with 200mm wide splitters and 100mm wide air gaps unless otherwise stated on the drawings.

3.4 Rectangular inline attenuator splitters shall be aerodynamically shaped on the entry and exit edges and shall be selected not to exceed the pressure drop at the design air flow rate as stated on the drawings.

3.5 The sound absorption material shall be surfaced by a lining designed to withstand abrasion at air velocities up to 20m/s.

3.6 The sound absorption material and lining shall be rot-proof, moisture repellant, non-flammable and shall not support fungi and/or bacterial growth.

3.7 When stated on the drawings, specialized linings shall be provided to the sound absorption material such as:

3.7.1 Perforated sheet,
3.7.2 Perforated sheet with Milinex lining
3.7.3 Wire mesh with Milinex lining

3.8 The fill in cylindrical attenuators shall be retained in place by pre-galvanised wire mesh with a thickness of 1.6mm unless stated otherwise on the drawings.
3.9 Cylindrical attenuators shall be provided with a centrally mounted cylindrical acoustic pod with aerodynamic entry and exit surfaces.

3.10 The sound attenuator must be able to withstand operating temperatures of up to 80°C unless stated otherwise on the drawings.

3.11 The following minimum dynamic insertion losses shall be obtained from sound attenuators:

3.11.1 Rectangular Attenuators

<table>
<thead>
<tr>
<th>Type</th>
<th>Octave Band - Mid Frequency Hz- CPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>Type 1 - 600 long</td>
<td>3</td>
</tr>
<tr>
<td>Type 2 - 900 long</td>
<td>5</td>
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<tr>
<td>Type 3 - 1200 long</td>
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<tr>
<td>Type 4 - 1500 long</td>
<td>8</td>
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<tr>
<td>Type 5 - 1800 long</td>
<td>9</td>
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<tr>
<td>Type 6 - 2100 long</td>
<td>10</td>
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<tr>
<td>Type 7 - 2400 long</td>
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3.11.2 Cylindrical Attenuators – 1 D Long

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
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<tr>
<td>Ø315 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø400 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø500 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø560 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø630 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø710 x 1.0D with Pod</td>
<td>3</td>
</tr>
<tr>
<td>Ø800 x 1.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø900 x 1.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø1000 x 1.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø1120 x 1.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø1250 x 1.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø1400 x 1.0D with Pod</td>
<td>5</td>
</tr>
<tr>
<td>Ø1600 x 1.0D with Pod</td>
<td>5</td>
</tr>
<tr>
<td>Ø1800 x 1.0D with Pod</td>
<td>5</td>
</tr>
<tr>
<td>Ø2000 x 1.0D with Pod</td>
<td>5</td>
</tr>
</tbody>
</table>
3.11.3 Cylindrical Attenuators – 2 D Long

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<th>Octave Band - Mid Frequency Hz- CPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>Ø315 x 2.0D with Pod</td>
<td>4</td>
</tr>
<tr>
<td>Ø400 x 2.0D with Pod</td>
<td>6</td>
</tr>
<tr>
<td>Ø500 x 2.0D with Pod</td>
<td>6</td>
</tr>
<tr>
<td>Ø560 x 2.0D with Pod</td>
<td>6</td>
</tr>
<tr>
<td>Ø630 x 2.0D with Pod</td>
<td>7</td>
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<tr>
<td>Ø710 x 2.0D with Pod</td>
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<td>Ø800 x 2.0D with Pod</td>
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<td>Ø900 x 2.0D with Pod</td>
<td>7</td>
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<tr>
<td>Ø1000 x 2.0D with Pod</td>
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<td>Ø1120 x 2.0D with Pod</td>
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<td>Ø1250 x 2.0D with Pod</td>
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<tr>
<td>Ø1400 x 2.0D with Pod</td>
<td>8</td>
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<tr>
<td>Ø1600 x 2.0D with Pod</td>
<td>8</td>
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<tr>
<td>Ø1800 x 2.0D with Pod</td>
<td>8</td>
</tr>
<tr>
<td>Ø2000 x 2.0D with Pod</td>
<td>8</td>
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</tbody>
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3.11.4 Acoustic Louvres

<table>
<thead>
<tr>
<th>Type</th>
<th>Octave Band - Mid Frequency Hz- CPS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
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<tr>
<td>Standard acoustic Louvre</td>
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<tr>
<td>High performance acoustic louvre</td>
<td>5</td>
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</tbody>
</table>

4. BUILDING RESTRAINT

4.1 Casings shall be constructed of galvanised steel sheet, flanged for connection to ductwork, complete with matching flanges. The thickness of sheet steel shall be not less than the thickness specified for ductwork of the same dimensions.

4.2 Sound attenuators shall be installed in accordance with manufacturer's recommendations.

5. "MEASUREMENT" TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION

5.1 Subcontractor shall supply the necessary field testing instruments and detailed description of field testing arrangement to prove a performance measurement accuracy of + 5% for the attenuator Acceptance Testing.

5.2 Certified test results shall be plotted on the official published and certified equipment performance graph/table to confirm that claimed performance is achieved.

5.3 The various tests as required by the Quality Management System, shall be demonstrated and accessible to the Engineer at all times for monitoring.

6. SCHEDULE

6.1 Refer to the layout drawings for schedules

6.2 Sound attenuators shall be installed in accordance with manufacturer's recommendations.

6.3 All figures given are for an altitude as specified in Part C3.1.
1. FUNCTIONAL PERFORMANCE

1.1 OPERATING RANGE
The duct pressure control station (further referred to as unit) shall maintain the downstream static pressure within 5% of the set point.

1.2 Provision must be made for the damper to be closed and/or opened remotely from the Building Management System if specified as such in the schedule. Under closed conditions, the leakage rate shall not be higher than is specified in the schedule.

1.3 A unit control panel shall be mounted remotely, in an easier accessible location, where the controller can be adjusted and instruments read without the need for steps or a flash light.

The control panel will house the static pressure controller, will give a read-out of the controlled static pressure and have the facility to read the incoming and outgoing control signals.

2. RELIABILITY AND AVAILABILITY

The unit shall be so installed that replacement shall not take longer than 2 hours when executed by qualified building maintenance staff.

2.2 MEAN TIME BETWEEN FAILURES
The minimum acceptable service life is 15 years with 3,000 operating hours per annum and 50,000 control cycles per annum, with a maximum deviation from this standard for 15% of the total number of items.

2.3 COMPREHENSIVE SERVICE AND MAINTENANCE CONTRACT
Only suppliers/manufacturers who offer, and submit proof that they can honour, a 5 year Comprehensive Maintenance Contract (renewable for another 5 years at the option of the Building Owner will be considered as acceptable suppliers. (Refer PART C4.7)

2.4 DOCUMENTATION
Supplier of unit shall submit service, maintenance trouble shooting, installation and testing instructions in order to obtain acceptance approval. Documentation shall be indexed in accordance with the equipment part of the O & M Manual Part C1.5 Section 18.

3. TECHNICAL RESTRAINTS

3.1 The damper blades shall be aerofoil shaped and manufactured from aluminium.

3.2 A mechanical stop shall be provided to prevent accidental damage to the damper blades as a result of mal-adjustment of controllers or actuators.

3.3 The damper casing shall be insulated to the same specification as for the ductwork of which it forms part.
4. **BUILDING RESTRAINTS**

4.1 The unit shall be so constructed that the noise level in a room located under the unit operating under specified conditions and separated from it through a standard lay in ceiling tile, shall not exceed the NC-level for the room as specified under clause C3.1.

4.2 Downstream sound attenuator shall be provided if necessary.

5. **“MEASUREMENT” TO CONFIRM EQUIPMENT COMPLIANCE WITH SPECIFICATION**

5.1 Subcontractor shall supply the necessary field testing instruments (air flow meters) and detailed description of field testing arrangement to prove a capacity/performance measurement accuracy of ± 10% for Terminal Acceptance Testing.

5.2 Performance testing of the terminal shall be done in a certified laboratory with formal testing and certification procedures, and results of test certified by a responsible person/Professional Engineer.

5.3 The various tests as required by the Quality Management System shall be demonstrated and be accessible to the Engineer at all times for monitoring.
### SCHEDULE - DUCT PRESSURE CONTROL STATION

<table>
<thead>
<tr>
<th>Identification</th>
<th>Performance</th>
<th>Optional Extras</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification No.:</td>
<td>- Identification No.:</td>
<td>- Remote control by BMS</td>
<td>1. All figures given are for an altitude as specified in Part C3.1.</td>
</tr>
<tr>
<td>Drawing No. Reference</td>
<td>- Drawing No. Reference</td>
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<tr>
<td>No. off</td>
<td>- No. off</td>
<td></td>
<td>2. Estimated for tendering purposes only. To be confirmed at time of equipment submission.</td>
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<table>
<thead>
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<th>Identification</th>
<th>Refer Note</th>
<th>Units</th>
<th>Tender</th>
<th>Offered</th>
<th>Tender</th>
<th>Offered</th>
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<tbody>
<tr>
<td>- Air volume</td>
<td>-</td>
<td>(l/s)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>- Nominal size</td>
<td>-</td>
<td>(mm*mm)</td>
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<tr>
<td>- Upstream static pressure (maximum)</td>
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<td>(Pa)</td>
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</tr>
<tr>
<td>- (minimum)</td>
<td>2</td>
<td>(Pa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>2</td>
<td>(Pa)</td>
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<tr>
<td>- Maximum pressure on damper when fully closed</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Leakage rate under above pressure conditions</td>
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<td>(%)</td>
<td></td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Optional Extras</td>
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<td></td>
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</tbody>
</table>

**NOTES**

1. All figures given are for an altitude as specified in Part C3.1.
2. Estimated for tendering purposes only. To be confirmed at time of equipment submission.
1. FUNCTIONAL PERFORMANCE

1.1 OPERATING RANGE

1.1.1 Dampers shall be located as shown on the drawings and shall be combination - Fire - Balancing dampers.

1.1.2 Dampers shall be designed to close automatically and remain tightly closed upon the operation of an approved fusible link or other heat actuated device, located where readily affected by an abnormal temperature in the duct. Device shall have a temperature rating approximately 20°C above the maximum temperature that would normally be encountered when the system is in operation or shutdown.

2. TECHNICAL RESTRAINTS

2.1 The open or closed status of the damper shall be indicated outside the casing.

2.2 Dampers shall be sized so that the free air space when open is not less than the connected duct free air space.

2.3 Dampers shall be installed so as to form part of a continuous barrier to passage of fire when in a closed position. Where a damper cannot be fitted immediately adjacent to the fire wall, the section of ducting between damper and wall shall be of at least the same metal thickness and fire rating as the damper casing.

2.4 Dampers shall be self-supporting in case of duct destruction due to heat. Care shall be exercised that the frame be set so that the closing device will be accessible.

2.5 Suitable hand openings with tightly fitted covers shall be provided to make dampers accessible for inspection and maintenance.

2.6 Dampers shall be selected for a minimum fire protection rating of two hours.

2.7 The fusible link shall be of the re-usable bi-metallic type.

2.8 The fusible link shall be:

- One time, rise of temperature: YES
- Re-usable, rise of temperature: NO
- Re-usable rise of temperature electrically energised: NO

3. AUTHORITIES

Dampers shall comply with the requirements of local authorities, SABS 193 NFPA Bulletin 90A and National Building Regulations Act.

4. SCHEDULE

Refer layout drawings for schedules.
## PART C4.1

### SCHEDULE OF DRAWINGS

**NOTE:** The drawings listed below and issued with this Selected Subcontract document illustrate the broad scope of the subcontract works. The Tenderer is referred to the Principal Contract Preliminaries, in this regard.

<table>
<thead>
<tr>
<th>DRAWING NO.</th>
<th>REV.</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>181017-M-A-4B1</td>
<td>0a</td>
<td>Basement HVAC Layout</td>
</tr>
<tr>
<td>181017-M-A-4GF</td>
<td>0f</td>
<td>Ground Floor HVAC Layout</td>
</tr>
<tr>
<td>181017-M-A-401</td>
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<td>First Floor HVAC Layout</td>
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<td>181017-M-A-402</td>
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<td>Second Floor HVAC Layout</td>
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<td>181017-M-A-4RF</td>
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<td>Roof HVAC Layout</td>
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</table>
PART C4.6

UNFIXED MATERIALS GUARANTEE
UNFIXED MATERIALS GUARANTEE
(To be provided by a Selected Subcontractor)

1 UNFIXED MATERIALS GUARANTEE ("Guarantee") by -

1.1 [_____] (Note 1) ("Guarantor")

in favour of -

1.2 [_____] ("Employer")

2 DEFINITIONS

In this guarantee, unless the context requires otherwise -

2.1 "Employer" shall mean ..............................................................

2.2 "Guarantor" shall mean the person or institution identified in 1.1 above;

2.3 "Contractor" shall mean [_____] (Note 2);

2.4 "Principal Agreement" shall mean the written agreement of building contract

2.4.1 which has been or shall be entered into between the Employer and the Contractor;

2.4.2 which comprises the agreement and the contract documents as defined therein;

2.4.3 in terms of which the Contractor has undertaken or shall undertake to execute and complete the following works -

[_____] (Note 3) ("Works");

2.5 "Subcontractor" shall mean the following body corporate or person who has been or shall be employed by the Contractor as a nominated or selected subcontractor under the Principal Agreement to perform the following subcontract works -

[_____] (Note 4) ("Subcontract Works");

2.6 "subcontract" shall mean the nominated or selected subcontract -

2.6.1 which has been entered into or shall be entered into between the Contractor and the Subcontractor; and

2.6.2 in terms of which the Subcontractor has been or shall be employed to complete the Subcontract Works;

2.7 "Works" shall mean the Works referred to in 2.4.3;

2.8 "Site" shall mean the Site upon which the Works shall be and/or, are being constructed;

2.9 "Guaranteed Amount" shall mean the amount of R [_____] (Note 5) which shall constitute the limit of the Guarantor's liability hereunder.
3 **BASIS**

It is the basis of this Guarantee that -

3.1 The Employer shall from time to time, subject to delivery to the Employer of this Guarantee, pay to the Contractor or the Subcontractor, in terms of the Principal Agreement, the value of materials and/or goods ("Unfixed Materials") which:

3.1.1 are intended for use in or to be built into the Works or the Subcontract works;

3.1.2 have been delivered to the Site or are still off Site; and

3.1.3 at the time of such payment to the Contractor or the Subcontractor have not been built into and/or affixed to the Works or the Subcontract Works; and,

3.2 Should the Employer pay the Contractor or the Subcontractor the value of any Unfixed Materials, the ownership of which does not pass to or vest in the Employer, the Guarantor shall, in the terms set forth in this Guarantee, refund to the Employer the value of such Unfixed Materials so paid to the Contractor or the Subcontractor; and

3.3 The Guarantor hereby acknowledges and agrees that -

3.3.1 It is conversant with the Principal Agreement and the subcontract and that each word or phrase as defined in clause 1.0 of the Principal Agreement shall, when utilised in this Guarantee, have the same meaning ascribed thereto in the Principal Agreement; and,

3.3.2 Reference herein to the Principal Agreement and/or the Subcontract and the reference thereto in terms of 3.3.1, shall not be construed to constitute this Guarantee as being a suretyship or an accessory obligation of any nature whatsoever.

4 **LIMIT TO GUARANTOR'S LIABILITY**

Notwithstanding anything to the contrary contained herein the Guarantor's liability to the Employer under this Guarantee shall be and is limited to the Guaranteed Amount.
5

THE GUARANTEE

5.1 Subject to the Guarantor's maximum liability referred to in 4, the Guarantor hereby binds itself unto and in favour of the Employer, as principal debtor and as such, hereby undertakes as a principal and independent obligation in favour of the Employer forthwith upon receipt by the Guarantor at its domicile address referred to in 6.2 of the documents identified in 5.1.1 and 5.1.2 hereof to pay to the Employer the sum of money referred to in 5.1.2, namely -

5.1.1 a written demand addressed to the Guarantor and issued by or on behalf of the Employer in which the Employer -

5.1.1.1 has recorded that such demand has been issued in terms of this Guarantee; and,

5.1.1.2 has demanded payment of a stated sum of money which -

5.1.1.2.1 does not exceed the Guaranteed Amount; and,

5.1.1.2.2 is equal to or is less than the value of the unfixed materials described in the statement of the Principal Agent which is referred to in 5.2; and,

5.1.2 a written statement prepared and signed by the Principal Agent which records -

5.1.2.1 the value and description of Unfixed Materials;

5.1.2.2 that the value of the Unfixed Materials referred to in 5.1.2.1 has been paid by the Employer to the Contractor or to the Subcontractor; and,

5.1.2.3 either that the unfixed materials referred to in 5.1.2.1 have despite demand therefor addressed to the Contractor, not been delivered to the Site or that such Unfixed Materials have, despite such demand, not been affixed to or built into the Works or the Subcontract Works or that the ownership of such Unfixed Materials has not passed to or vested in the Employer or that a person other than the Employer has claimed ownership of the Unfixed Materials referred to in 5.1.2.1.

5.2 The Guarantor shall not be entitled to withhold payment to the Employer in terms of 5.1 even if the Guarantor contends that the Guarantor is not obliged to make such payment on the basis of any fact or allegation which would constitute a legal or equitable defence to or a discharge of any claim by the Employer under this Guarantee; provided however that the foregoing provisions of this 5.2 shall not be construed as preventing the Guarantor from reclaiming any amount paid under protest pursuant to a claim by the Employer in terms of this 5.2 if the Guarantor contends that it was not obliged to pay such amount.

6. GENERAL

6.1 The Employer shall have the absolute right to arrange his affairs with the Contractor and/or the Subcontractor under the Principal Agreement the Subcontract or otherwise in any manner which the Employer deems fit and the Guarantor shall not have the right to claim his release from this Guarantee on account of any conduct alleged to be prejudicial to the Guarantor. Without derogating from the generality of the foregoing -

6.1.1 any compromise by the Employer and the Contractor relative to the Principal Agreement and/or the Subcontract and/or the parties' respective obligations thereunder; and/or

6.1.2 any amendment or variation of or addition to the provisions of the Principal Agreement, the Subcontract and/or the parties' respective obligations thereunder;

6.1.3 any revision of the construction period, indulgence, release and/or waiver of the Employer's and/or the Contractor's and/or the Subcontractor's obligations under the Principal Agreement and/or the Subcontract,

6.1.4 shall not affect the validity of this Guarantee and shall not afford the Guarantor the right to claim its release from its undertakings and/or obligations under this Guarantee.
6.2 The Guarantor hereby chooses domicilium citandi et executandi for all purposes in connection with this Guarantee and any legal proceedings instituted on the basis of this Guarantee at the following address -

[ ] (Note 6);

6.3 This Guarantee is neither negotiable nor transferable and shall be returned to the Guarantor upon it having lapsed in terms of 6.4;

6.4 This Guarantee shall lapse and be of no further binding force of effect upon the earlier of -

6.4.1 the date of issue of Certificate of Final Completion by the Principal agent in terms of the Principal Agreement; or
6.4.2 the date upon which the Guaranteed Amount shall have been paid to the Employer in full in terms of this Guarantee.

6.5 The rights of the Employer under this Guarantee shall in no way be affected or diminished if the Employer at any time obtains additional suretyships, guarantees, securities or indemnities in connection with the obligations of the Guarantor hereunder or in connection with the obligations of the Contractor under the Principal Agreement.

6.6 Solely for the sake of clarity and without prejudice to or limitation of the aforesaid provisions of this Guarantee, it is recorded that the Guarantor renounces the benefits of all otherwise applicable legal immunities, defences and exceptions to the extent that they would be applicable in the absence of this renunciation, including the defences and exceptions of "cession of actions", "excussion", "division", "de duobus vel pluribus reis debendi", "non causa debiti", "errore calculi", "no value received" and "revision of accounts", with the meaning and effect of all of which the Guarantor declares itself to be fully acquainted.

6.7 As part of the Guarantor’s liability in terms hereof, the Guarantor shall pay the amount of any costs, charges and expenses of whatever nature incurred by the Employer in securing or endeavouring to secure fulfilment of the Guarantor’s obligations hereunder, including, without limitation, collection commission and legal costs on the scale as between an attorney and his own client.

6.8 This document constitutes the sole record of the agreement between the Employer and the Guarantor in regard to the subject matter hereof.

6.9 Neither the Guarantor nor the Employer shall be bound by any express or implied term, representation, warranty, promise or the like not recorded herein, but the provisions hereof are without prejudice to such other rights as the Employer may have at law.

6.10 No addition to, variation, or unilateral or consensual cancellation of this Guarantee shall be of any force or effect unless in writing and signed by or on behalf of the Employer and the Guarantor.

6.11 No indulgence which may be granted to the Guarantor by the Employer shall constitute a waiver of any of the rights of the Employer which shall not thereby be precluded from exercising any right against the Guarantor which may have arisen in the past or which may arise in the future.

6.12 If any provision of this Guarantee should be found by a competent court to be wholly or partly invalid or unenforceable then this Guarantee shall be severable in respect of the provision in question (to the extent that it is invalid, unenforceable or unlawful) and the remaining provisions of this Guarantee shall remain in full force and effect.

7. NO PRIVITY OF CONTRACT

The provisions of this Guarantee shall not create any privity of contract between the Employer and the Subcontractor under and in respect of the Principal Agreement or the subcontract.
8. **EXECUTION**

SIGNED at [ ] on this [ ] day of [ ] by (hereafter "Signatory") (Note 7) on behalf of the Guarantor, which Signatory -

8.1 has been duly authorised to bind the Guarantor to this Guarantee by virtue of the attached resolution (Note 8);

8.2 in his personal capacity (that it not representative capacity) hereby warrants in favour of the Employer that he has been invested with the necessary authority to bind the Guarantor to the provisions of this Guarantee.

AS WITNESSES:

1. ____________________

2. ____________________

(Note 9) ____________________ The Signatory on behalf of the Guarantor

**NOTES**

Note 1: Insert the Guarantor's name and registration number.

Note 2: Insert the Contractor's name and registration number.

Note 3: Insert description of the Contract Works.

Note 4: Insert description of the Subcontract Works.

Note 5: Insert the maximum Guaranteed Amount.

Note 6: Insert Guarantor's physical address (not Post Box Number).

Note 7: Insert the name of the Signatory on behalf of the Guarantor.

Note 8: Attach a certified copy of resolution by the directors of the Guarantor authorising the Signatory to sign this Guarantee on its behalf.

Note 9: The Signatory and the witnesses must initial each page hereof and sign clause 8 in full.
PART C4.7

MAINTENANCE AGREEMENT
[ ] **Job Name**

AIR-CONDITIONING PLANT MAINTENANCE AGREEMENT

between

[ ] **Employer**

and

[ ]

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AIR-CONDITIONING PLANT MAINTENANCE AGREEMENT

between

[ ]

("Employer")

and

[ ]

("Contractor")

1 INTERPRETATION

In this Agreement, clause headings are for convenience and shall not be used in its interpretation and, unless the context clearly indicates a contrary intention -

1.1 an expression which denotes -

1.1.1 any gender includes the other genders;

1.1.2 a natural person includes an artificial or juristic person and vice versa;

1.1.3 the singular includes the plural and vice versa;

1.2 the following expressions shall bear the meanings assigned to them below and cognate expressions bear corresponding meanings -

1.2.1 "Agreement" means this Agreement and the appendices thereto;

1.2.2 "Annual Maintenance Consideration" means any Annual Maintenance Consideration in respect of which the Contractor shall have submitted a Tender under and in terms of the Subcontract to supply and instal the Equipment referred to under the definition of Certificate of Works Completion;

1.2.3 "Call-Back Rate" means the number of times the Contractor shall, in each twelve month period of this Agreement, be required by the Employer to provide Corrective Maintenance in respect of the Equipment, or any part thereof;

1.2.4 "Call-Back Response Time" means the call-back response time(s) referred to in 4.8;

1.2.5 "Certificate of Works Completion" means the Certificate of Works Completion as shall be issued by the Principal Agent in terms of the Principal Building Agreement according to which the Building in [ ] shall be or has been constructed for the Employer, by a principal building Contractor to which the Contractor has contracted, by means of a subcontract to supply and install the Equipment in the aforementioned Building;

1.2.6 "Commencement Date" means the first anniversary of the Final Completion Date;

1.2.7 "Contractor" means [ ];

1.2.8 "Corrective Maintenance means repairs maintenance to Equipment failing or malfunctioning while in service in order to correct such failing or malfunctioning and to restore the Equipment to normal functioning and satisfactory operating condition;
1.2.9 "Employer" means [ ]

1.2.10 "Equipment" means the entire air-conditioning plant and equipment to be installed in or situated in the Employer's building [ ]

1.2.11 "Equipment Manufacturers Maintenance Instructions" means the maintenance instructions which -

1.2.11.1 Are contained within the Operating and Maintenance Manuals;

1.2.11.2 have been prepared and issued by any manufacturer or supplier of the Equipment;

1.2.11.3 shall have been delivered to the Employer by the contractor or subcontractor which shall have supplied and/or installed the Equipment;

1.2.12 "Final Completion Date" means the date specified in the Certificate of Works Completion;

1.2.13 "High Priority Equipment" means equipment which affects the performance of HVAC system in critical areas or substantial portions of the HVAC system eg. chillers, pumps, computer room AC units, smoke extraction fans etc;

1.2.14 "Low Priority Equipment" means equipment which affect performance of the HVAC system in a small portion of a comfort zone eg. diffusers, ceiling FCU etc;

1.2.15 "Maintenance Activity Schedules" means the maintenance activity schedules as referred to in 13;

1.2.16 "Maintenance Management Systems means the management system referred to in 7;

1.2.17 "Maintenance Programme" means the Maintenance programme referred to in 8;

1.2.18 "Maintenance Quality Assurance means the quality assurance and standards referred to in 6;

1.2.19 "Maintenance Service" means the supply by the Contractor of Predictive Maintenance, Preventative Maintenance and Corrective Maintenance in respect of the Equipment in terms of this Agreement;

1.2.20 "Maximum Equipment Downtime" means the Maximum Equipment Downtime referred to in 14;

1.2.21 "Medium Priority Equipment" means equipment which affect performance of HVAC sub-systems in a local comfort zone or non critical areas eg. VAV AHU's, tea kitchen ventilation etc;

1.2.22 "Operating and Maintenance Manuals" means the operating and maintenance manuals which -

1.2.22.1 have been prepared and issued by any manufacturer and/or supplier of the Equipment; and

1.2.22.2 shall have been delivered to the Employer by the contractor or the subcontractor which shall have supplied and/or installed the Equipment;

1.2.23 "Parties" means the Employer and the Contractor;

1.2.24 "Party" means either the Employer or the Contractor;

1.2.25 "Predictive Maintenance" means the collection of data, performing of tests and inspections, determining and monitoring trends to enable timely identification of, and to predict, degradation of the Equipment, or any part thereof, or loss of performance in order that Preventative Maintenance can be performed prior to Equipment failure;
1.2.26 "Preventative Maintenance" means maintenance carried out within the anticipated endurance time of the Equipment or any part thereof (including the replacement of worn components when components have reached the end of their operational life or if components are no longer capable of meeting their operational design criteria) in order to ensure the safe, efficient and reliable operation of the Equipment according to their design criteria;

1.2.27 "Response Time" means the response times referred to in 4.8;

1.2.28 "Site" means the Employer's Building referred to in [ ];

1.3 any reference to any statute, regulation or other legislation shall be a reference to that statute, regulation or other legislation as at the signature date, and as amended or substituted from time to time;

1.4 if any provision in a definition is a substantive provision conferring a right or imposing an obligation on any party then, notwithstanding that it is only in a definition, effect shall be given to that provision as if it were a substantive provision in the body of this agreement;

1.5 where any term is defined within a particular clause, other than this 1, that term shall bear the meaning ascribed to it in that clause wherever it is used in this agreement;

1.6 where any number of days is to be calculated from a particular day, such number shall be calculated as excluding such particular day and commencing on the next day. If the last day of such number so calculated falls on a day which is not a business day, the last day shall be deemed to be the next succeeding day which is a business day;

1.7 any reference to days (other than a reference to business days), months or years shall be a reference to calendar days, months or years, as the case may be;

1.8 any term which refers to a South African legal concept or process (for example, without limiting the aforesaid, winding-up or curatorship) shall be deemed to include a reference to the equivalent or analogous concept or process in any other jurisdiction in which this agreement may apply or to the laws of which a party may be or become subject.

2 BASIS

It is the basis of this Agreement that the Contractor shall, during the period of this Agreement, and any extensions thereof, supply the Employer with a Maintenance Service for and in respect of the Equipment in terms of the provisions contained in this Agreement, the Operating and Maintenance Manuals and the Equipment Manufacturers Maintenance Instructions.

3 SCOPE

3.1 The Maintenance Service which shall be supplied by the Contractor to the Employer shall -

3.1.1 consist of Corrective Maintenance, Preventative Maintenance and Predictive Maintenance;

3.1.2 achieve the maintenance objectives set forth in 4 below; and

3.1.3 be performed and supplied in accordance with the provisions of this Agreement.

4 MAINTENANCE OBJECTIVES

Without limiting the Contractor's obligations in terms of this Agreement, the Contractor shall, by means of the supply of the Maintenance Service in terms of 2 and 3 ensure -

4.1 the safety and comfort of persons using the Equipment;
4.2 the accuracy and reliability of the performance of the Equipment;

4.3 that the Maintenance Service is carried out at all times irrespective of whether or not such maintenance is necessitated by faulty design, faulty materials or faulty workmanship employed in connection with the manufacture and/or installation of the Equipment, or by reason of fair wear and tear;

4.4 that the Maintenance Service is carried out in accordance with the Maintenance Programme, the Maintenance Quality Assurance and the Maintenance Management System;

4.5 that the Equipment and associated spares are kept clean and presentable at all times;

4.6 that the frequency of Equipment break-downs shall not result in the target number of (8) eight call-backs per annum being exceeded on the basis that -

4.6.1 the actual call-back rate shall be recorded by the Contractor on a monthly basis and assessed and calculated on a twelve monthly basis;

4.6.2 each twelve month period referred to in 4.6.1 shall, in each case, be the twelve month period preceding each anniversary of the Commencement Date;

4.7 that the Maintenance Programme shall be structured and implemented so as to ensure that a Maximum Equipment Downtime shall not be exceeded;

4.8 that at any time of the day or night, seven days a week, inclusive of statutory holidays, throughout the period of this Agreement, the Contractor (his Technician) shall be available to respond to call-backs with regard to breakdowns of Equipment on the basis that -

4.8.1 the response times shall be reckoned from the time the call is received by the Contractor to the time the Contractor's technician arrives on Site;

4.8.2 the response time during normal working hours shall be two hours;

4.8.3 the response time outside of normal working hours shall be three hours;

5 MAINTENANCE WORK

5.1 Maintenance Work comprises –

5.1.1 Predictive Maintenance;

5.1.2 Preventative Maintenance;

5.1.3 Corrective Maintenance.

5.2 The Contractor shall perform Predictive Maintenance in accordance with the Equipment Manufacturer's Maintenance Instructions and the Operating and Maintenance Manuals and in accordance with good maintenance practice to ensure that the objectives in 4 are attained in respect of the Equipment.

5.3 The Contractor shall, following on Predictive Maintenance and as may be evidenced thereby, report any trends detected of Equipment degradation, loss of performance or frequency of failure to the Employer.

5.4 The Contractor shall perform the Preventative Maintenance in accordance with the Equipment Manufacturer's Maintenance Instructions and the Operating and Maintenance Manuals, and as may become evident by Predictive Maintenance to ensure achievement of the objectives in 4.
5.5 Without limiting the generality of 5.4, the Preventative Maintenance shall comply with the Maintenance Activities Schedules.

5.6 The Contractor shall arrange with the Employer and obtain approval for the date, time and duration when Equipment shall be out of service for purposes of performing the Preventative Maintenance and/or the Predictive Maintenance provided that the Maximum Equipment Downtimes shall not be exceeded by such Maintenance Service.

5.7 The Contractor shall perform the Corrective Maintenance on broken down Equipment within the Maximum Equipment Downtimes.

5.8 Following Corrective Maintenance, the Contractor shall deliver a written report to the Employer recording -

- date and time of the failure;
- reason for the failure;
- date and time when Corrective Maintenance completed;
- details of Corrective Maintenance supplied; and
- the results of any post Corrective Maintenance testing performed to ensure satisfactory operation of the Equipment.

5.9 Without limiting the generality of 5.1 through to 5.9, it shall be the obligation of the Contractor in connection with the Maintenance Service -

- to ensure that Maintenance Service shall be performed by Competent persons who are qualified Air-Conditioning Equipment Mechanic/s experienced and skilled in maintaining equipment similar to which are subject matter of this Agreement and who are employed and supervised by the Contractor. The Employer reserves the right to request and be granted copies of certificates of qualification/competence for the foregoing technicians;
- to maintain locally or nationally an inventory of all regularly wearing parts or parts relative to the Equipment whose failure can be reasonably predicted/anticipated;
- to provide and keep or have access to a national or international inventory of all wearing parts or parts relative to the Equipment’s maintenance and operation. The Employer reserves the right to inspect the spares inventory at any time during the term of this Agreement;
- to ensure that major Equipment components not included in the local or national inventory of spares are sourced and ordered prior to these components failing or not being able to deliver the Maintenance Service in terms of this Agreement;
- to supply, repair and replace all parts of every description made necessary by Preventative or Corrective Maintenance without expense to the Employer when such replacement or repair is deemed necessary by the Contractor in accordance with this Agreement. Only parts that are correctly designed, manufactured and suitable in all respects, shall be used;
- to replace all parts timeously, thereby limiting the incidence of break-downs, unplanned maintenance or repair and consequently maintain maximum equipment operation;
- to ensure that the break-time does not exceed the Maximum Equipment Downtime;
- to carry out all software, print and Equipment changes or revisions, which may become necessary to ensure an operation that conforms to the original design and performance specification or a subsequent, documented and approved revised specification, without expense to the Employer;
- to notify the Employer of all improvements or revisions related to the Equipment. These notifications shall take the form of technical notices or sales releases under a covering letter from the Contractor;
5.9.10 to ensure that all wiring diagrams and other drawings of a technical nature related to the Equipment kept up to date and are available for the sole use of the Contractor, Employer or its technical personnel. The wiring diagrams enclosed in plastic protection sleeves shall be located and retained in suitably sized and constructed steel cabinets/enclosures situated within the machine room. Any amendments to these wiring diagrams shall be marked up as a revision and the diagrams reprinted by the Contractor within a ten day period after such change occurring;

5.9.11 to provide within a one month period after being appointed for the Maintenance Service under this Agreement, a maintenance site register located in the machine room and maintain accurate records of all service procedures, site visits, stoppages, breakdowns, planned repairs and safety related Equipment operation tests and checks;

5.9.12 to provide within a one month period after being appointed for the Maintenance Service under this Agreement, a customer communication logbook situated at a mutually agreed location for effective two-way communication, between the Employer and the Contractor's personnel. This logbook shall accurately record each and every site visit;

5.9.13 to provide on request by the Employer or its duly appointed agents, computer generated reports detailing a history of the equipment call-backs, repairs and breakdown repairs;

5.9.14 to inform the Employer verbally and in writing and act immediately on any potentially hazardous or undesirable situation which may cause harm to persons or which may damage or reduce the life expectancy of the Equipment, even if the hazardous or undesirable situation does not form part of the Contractor's responsibilities;

5.9.15 to inform the Employer in writing at least forty-eight hours prior to carrying out of any modification to the existing Equipment deemed necessary by the Contractor, even if this modification may benefit the equipment or if the cost of this modification is for the Contractor's account.

6 QUALITY ASSURANCE

6.1 The Contractor shall, as an integral part of the Maintenance Service, and the supply thereof to the Employer, adopt a quality system and the standards which shall comply with SABS 150 9001:1994 or SABS 150 9002:1994 as appropriate.

6.2 The Contractor shall, forthwith after the Commencement Date, provide the Employer with satisfactory written proof of the Contractor's certification in respect of the quality system in 6.1.

6.3 If the Contractor is not in possession of a valid certificate, as referred to in 6.2, he shall submit to the Employer, forthwith after the Commencement Date -

6.3.1 a written advice of the steps the Contractor shall then currently be taking towards achieving such certification and the date by which such certification shall be accomplished; and

6.3.2 copies of the Contractor's programme of activities leading to such certification and a statement of progress to date; which information the Employer shall be entitled to verify; and

6.3.3 the Contractor's then current quality assurance system which shall be adjusted in such reasonable respects by the Contractor as the Employer may require in writing

7 MAINTENANCE MANAGEMENT SYSTEM

The Contractor shall, with effect from the Commencement Date, implement the following Maintenance Management System, shall ensure that the following information in respect of the system remains current during the period of this Agreement and shall submit such information to the Employer on the latter's request, or failing which, on such regular basis as shall be agreed with the Employer -
7.1 **SPARE PARTS INVENTORY**

Schedule of spare parts required to ensure that Maximum Equipment Downtimes are not exceeded, and updated inventory of spare parts and parts on order;

7.2 **JOB CARDS**

The Contractor shall draw up the necessary Job Cards from the Maintenance Programme, or in response to emergency call outs, or equipment failure, and hand the completed cards to the Employer for verification and acceptance that the work has been duly executed. The format of the Job Cards shall be approved by the Employer;

7.3 **COST CONTROL**

Obtaining and recording of quotations for materials or equipment, selecting the most competitive Supplier, obtaining approval from the Employer before placing orders, and monthly submission of proven cost of materials and equipment to the Employer;

7.4 **PERFORMANCE LOGGING**

Check performance of top and medium priority sub-systems and controls against the control drawings, commissioning date and set points on a monthly basis and re-commission or re-calibrate if necessary;

7.5 **COMPLAINTS**

Record complaints' date, time and details, and details of the faults detected and corrective action taken;

7.6 **REPORTING**

Preparation of Reports, on the half yearly inspections and on repairs which have taken place during the period preceding the inspection, to be submitted not later than two weeks after the inspection to the Employer.

Monthly water treatment reports, bi-annual oil sample analysis reports, and annual vibration test reports on high priority equipment;

7.7 **EQUIPMENT INVENTORY**

Provide and maintain an up-to-date equipment inventory;

7.8 **EQUIPMENT HISTORY SYSTEM**

Implement a system whereby each item on equipment's history of maintenance and repairs are recorded and retrievable at all times.

8 **MAINTENANCE PROGRAMME**

8.1 The Contractor shall forthwith after the Commencement Date for the ensuing twelve month period, and thereafter of each anniversary of the Commencement Date, for each ensuing twelve month period of this Agreement, prepare and deliver to the Employer a Maintenance Programme in weekly subdivisions indicating when specific Predictive Maintenance and Preventative Maintenance shall be performed in respect of the Equipment.

8.2 The Maintenance Programme in 8.1 shall be prepared in accordance with the provisions of this Agreement, the Equipment Manufacturer's Maintenance Instructions and the Operating and Maintenance Manuals.

8.3 The frequency of maintenance activities shall be in accordance with the Equipment Manufacturer's Maintenance Instructions and trends obtained from Predictive Maintenance test results and other Predictive Maintenance information.
8.4 The Contractor shall monitor maintenance progress against the Maintenance Programme and shall submit monthly progress reports to the Employer.

8.5 In the event of any delays against the Maintenance Programme, the Contractor shall expedite the Maintenance Service to make up any delays, in accordance with this Agreement.

8.6 The Contractor shall deploy sufficient staff to ensure completion of the Maintenance Service within the Maintenance Programme and within normal working hours.

9 MAINTENANCE STAFF AND MEETINGS

9.1 The Contractor shall employ and manage his maintenance staff to ensure timely, efficient execution of the Maintenance Services with minimum interruption to the Employer, and in accordance with the provisions of this Agreement.

9.2 The Contractor shall attend maintenance co-ordination meetings and any other meetings called by the Employer.

10 LIMITATION OF RESPONSIBILITY OF CONTRACTOR

10.1 The Contractor shall not be obliged in terms of this Agreement to provide a Maintenance Service in respect of repairs, replacement or services necessitated by the improper operation of Equipment or negligence of Employer's staff or misuse of the Equipment, or from any other cause beyond the reasonable control of the Contractor, except for defective design, workmanship or materials employed in respect of the Equipment or normal wear and tear thereof.

10.2 The Contractor shall not in terms hereof be obliged to furnish any additional Equipment or alterations thereto as recommended by the Insurance Companies or Authorities.

10.3 In the event that unauthorised additions, alterations, repairs or adjustments are made to the Equipment by others resulting in mechanical damage, the Contractor shall not be liable under this Agreement to provide a Maintenance Service in respect thereof.

11 GENERAL RESPONSIBILITIES OF CONTRACTOR

11.1 GENERAL RESPONSIBILITIES OF CONTRACTOR

11.1.1 The Contractor must be fully conversant and experienced with the type of Equipment installed and must be capable of rectifying malfunctioning of Equipment installed.

11.1.2 The Contractor guarantees performance at all times of the Equipment, subject to proper operation of the Equipment by the Employer as defined by the Operating and Maintenance Manual, except for the specified routine and annual maintenance and breakdown times.

11.1.3 The Contractor shall perform as a minimum the service and maintenance work as specified in this Agreement and as contained in the maintenance schedules in the Operating and Maintenance Manuals and the Equipment Manufacturers Maintenance Instructions of the Equipment.

11.1.4 The Contractor shall ensure that, in consultation with the Employer, all his activities are carried out with a view to optimising the energy consumption of the Equipment in the buildings.

11.1.5 The Contractor shall abide by the Employer's housekeeping rules.

11.1.6 In addition to the equipment contained in the Equipment Inventory, the Contractor shall maintain as the need arises all general items not provided with specific maintenance instructions. These items shall include but not be limited to the following -
11.1.6.1 **Housekeeping**

Replace all globes and fluorescent tubes in plant room areas (globes and fluorescent tubes shall be drawn from the Employer's store). Cleaning and general painting in plantroom areas;

11.1.6.2 **General HVAC Electrical**

Perform any HVAC Electrical work not specifically associated with DB's and MCC's in the Equipment Inventory;

11.1.6.3 **Piping**

Maintain all refrigerant chilled water, hot water, condenser water, make-up water, and drain piping including supports. Inspect for any repair corrosion, any other forms of damage and leaks;

11.1.6.4 **Ductwork and Attenuators**

Inspect for and repair corrosion or mechanical damage to ducting, attenuators and their supports;

11.1.6.5 **Grilles and Constant Volume Diffusers**

Inspect and repair method of fixing, balancing device and paint touch up;

11.1.6.6 **Insulation**

Inspect and repair all damage to refrigerant piping, chilled and hot water piping, and duct insulation and maintain integrity of vapour barriers;

11.1.6.7 **Corrosion Protection**

Inspect and repair corrosion;

11.1.6.8 **Water Treatment**

Provide water treatment including chemicals in accordance with the recommendations of the Specialist. Direct Subcontractor appointed by the Contractor. Perform monthly analysis with reports. Water samples for Legionella testing will be taken to the CSIR or the South African Institute for Medical Research for analysis and reporting twice a year, once in June/July and once in January/February on all Equipment. The results of such tests shall be delivered to the Employer forthwith after the receipt thereof by the Contractor in each case;

11.1.6.9 **Filters**

Clean filters and replace damaged filters;

11.1.6.10 **Flexible Ducting**

Inspect and repair flexible ducting to diffusers, fans etc;

11.1.6.11 **Flexible Hoses**

Inspect flexible water hoses and connections for deterioration and replace/repair where required;
11.1.6.12  **Lubrication**

Lubricate all bearings and movable parts in accordance with the Supplier's recommendations.

**12  EMPLOYER'S OBLIGATIONS**

In addition to its other undertaking and obligations under this Agreement, the Employer shall -

12.1 perform simple trouble diagnosis on occurrence of fault, logging in logbook and reporting to Contractor by both telephone and facsimile;

12.2 provide safe prompt and reasonable access to the Contractor for Maintenance Service activities, as well as use of all necessary facilities;

12.3 return of all substitute equipment installed on a temporary basis to keep the Equipment running;

12.4 sign off the Contractor's Job Cards to certify that work has been done by the Contractor, but not accepting responsibility for the quality and adequacy of the work performed;

12.5 brief the Contractor on general housekeeping rules;

12.6 approve quotations submitted by the Contractor for spares and materials;

12.7 record equipment downtimes;

12.8 appoint a responsible person for operating the Equipment;

12.9 advise the Contractor immediately the Equipment malfunctions or becomes inoperative;

12.10 not to authorise or allow any person/s other than the Contractor or its duly authorised employees or agents to carry out any maintenance work on the Equipment during the currency of the Agreement, unless the prior written consent from the Contractor has been obtained. Should any work be carried out by any other company or person, prior to or during the term of the Agreement, the Contractor shall not be liable for any act, occurrence or omission on the part of such company or person/s or equipment supplied;

12.11 immediately notify the Contractor of any injury or harm to any person or property resulting from the usage of the Equipment and to make available all relevant information pertaining to equipment incidents;

12.12 ensure that the Contractor's workmen shall at all reasonable times have free and undisturbed access to the Equipment for the effective execution of normal maintenance procedures in accordance with this Agreement;

12.13 instruct the Contractor on any technical queries;

12.14 instruct the Contractor on any actions as may be required from trends highlighted by the Predictive Maintenance Testing;

12.15 instruct the Contractor on required course of action following catastrophic failures, or failures of high priority Equipment;

12.16 analyse Post Maintenance Test results and instruct the Contractor on corrective actions required;

12.17 chair and record Maintenance Co-ordination and Technical meetings;

12.18 monitor progress against the Maintenance Programme.
13 MAINTENANCE ACTIVITY SCHEDULES

13.1 The Contractor shall forthwith after the Commencement Date, prepare and deliver to the Employer Maintenance Activity Schedules relative to the Equipment in accordance with the Operating and Maintenance Manuals and/or the Equipment Manufacturer's Maintenance Instructions.

13.2 The Maintenance Activity Schedules shall be in such format as shall be approved by the Employer and shall be prepared by the Contractor and delivered to the Employer with such frequency and such intervals as shall reasonably be required by the Employer.

13.3 A specimen Maintenance Activity Schedule is attached hereto as Appendix 1 on the basis that in the event of the Contractor's Maintenance Activity Schedules, to be prepared in accordance with 13.1 and 13.2, conforming to the format of Appendix 1, it shall be deemed that the Employer has, as required under 13.2, approved the format thereof.

14 MAXIMUM EQUIPMENT DOWNTIMES

14.1 The Contractor shall plan and execute this Agreement in such a way, and ensure that spares, materials and staff are sufficiently available, to limit the downtime of the Equipment to the following Maximum Equipment Downtimes.

14.2 Planning of Predictive and Preventative Maintenance must ensure that there will be no interruption to comfort conditions or services provided by the Equipment.

14.3 The following Maximum Equipment Downtimes shall apply to this Agreement –

14.3.1 High Priority Equipment

Preventative Maintenance Major Service 2 Hours
Preventative Maintenance Minor Service 1 Hour
Corrective Maintenance for Breakdowns 1 Day

14.3.2 Medium Priority Equipment

Preventative Maintenance Major Service 4 Hours
Preventative Maintenance Minor Service 2 Hours
Corrective Maintenance for Breakdowns 2 Days

14.3.3 Low Priority Equipment

Preventative Maintenance Major Service 8 Hours
Preventative Maintenance Minor Service 4 Hours
Corrective Maintenance for Breakdowns 4 Days

15 INSPECTIONS

15.1 The Employer or its duly appointed agents shall retain the right to witness and/or verify the performance of any maintenance work by the Contractor in terms hereof at any time.

15.2 CONTRACTOR'S ANNUAL INSPECTIONS/SURVEYS

15.2.1 To enable the Contractor effectively to monitor the Equipment’s Maintenance Service, detailed annual inspections of the Equipment shall be undertaken by the Contractor's senior personnel (supervisor level);

15.2.2 The details of the annual inspections, date of inspection and the condition of the Equipment shall be recorded on a checklist signed and certified by the Contractor's Representative.

15.2.3 Should any defects or remedial work be required in terms of the Annual Inspection, the Contractor shall expeditiously undertake the Corrective Maintenance work. Should any of the items noted in the Annual
Inspection not be rectified within a two week period, the Contractor shall forward the Employer with a copy of a detailed works programme.

15.2.4 The Employer or its duly appointed agents shall have the right to request copies of the Annual Inspection checklists.

15.3 INDEPENDENT INSPECTIONS

15.3.1 The Employer shall have the right to authorise independent inspections of individual or entire Equipment installations using suitably qualified personnel at any time and the results of such inspections shall be promptly communicated in writing to the Contractor. Should any defects or remedial work be required in respect of Equipment in terms of this Agreement, the Contractor shall expeditiously undertake within a mutually agreed time period the Corrective Maintenance. When the Contractor's work has been completed satisfactorily, the Employer or its duly appointed agent(s) shall be notified in writing. In the opinion of the Employer, a further follow-up inspection by the Employer or its agent(s) may be conducted.

15.3.2 Should the follow-up inspection show that the work as agreed and undertaken by the Contractor has not been satisfactorily carried out, the procedure as detailed in 15.3.1 shall be repeated until the established standard of maintenance has been attained.

15.3.3 The Independent Inspections under 15.3.1 and 15.3.2 shall in no way limit the Contractor's responsibility with respect to any obligation or liabilities in terms of this Agreement.

16 MAINTENANCE CONSIDERATION REPLACEMENT PARTS FACILITIES BONUS

16.1 For purposes of this clause 16, unless the context requires otherwise -

16.1.1 "Monthly Maintenance Charge" has the meaning ascribed thereto in 16.2;

16.1.2 "Employer's Parts Stock" means those replacement parts, relative to the Equipment, which the Contractor shall, in terms of the Tender, have stipulated, shall be acquired and maintained by the Employer on site at its cost or failing which as shall be indicated by the Contractor in each Maintenance Programme delivered in terms of 8; provided however that if the Employer, in its sole discretion, regards the Employer's Parts Stock so indicated to be unreasonable in the circumstances, the Employer's Parts Stock shall be determined by any independent consulting engineer appointed by the Employer for such purposes which consulting engineer's determination shall be final and binding on both the Employer and the Contractor;

16.1.3 "Tender" means the tender and the tender documents which the Contractor shall, as a subcontractor, have submitted for purposes of executing the works involving the supply and installation of the Equipment in its relevant building;

16.1.4 "Tender Mark-up" means the percentage mark-up which the Contractor shall have indicated in the Tender, he shall require in respect of the supply of replacement parts other than the Employer's Parts Stock.

16.2 Subject to 16.3, the remuneration payable by the Employer to the Contractor in respect of the supply of the Maintenance Service under this Agreement, shall be the Annual Maintenance Consideration which shall, in addition to VAT thereon, be paid by the Employer to the Contractor during each twelve monthly period of this Agreement, in twelve equal instalments ("Monthly Maintenance Charge") on the last business day of every month, the first of which instalments shall be so paid on the last business day of the month within which the Commencement Date falls, and the subsequent of which instalments shall be so paid on the last business day of each succeeding month; provided that the monthly instalment for the period from the Commencement Date to the end of the month in which the Commencement Date falls, shall be pro rated on the basis of a thirty day month.
16.3 The Annual Maintenance Consideration shall be adjusted annually on the anniversary of the Commencement Date according to the following escalation formula -

\[
AAMC = \frac{AMC \times CPI}{CPI}
\]

where

AAMC is the adjusted Annual Maintenance Consideration payable as from each anniversary of the Commencement Date;

AMC is the Annual Maintenance Consideration payable as at the Commencement Date for the first annual period of this Agreement;

CPI is the Consumer Price Index on each anniversary of the Commencement Date on the basis that the reference herein to the Consumer Price Index is a reference to the Consumer Price Index for all expenditure groups, Metropolitan and other areas (Base 1995 = 100) as published from time to time by Statistics South Africa in Statistical Release P0141.1 provided that if after the commencement date, such index shall cease to be published the Parties shall use such other index as may be available and acceptable to both of them, or failing such acceptance on index determined in writing as fair and reasonable by the independent chartered accountants employed at the time by the Employer to audit its books of account; and

CPI is the Consumer Price Index on the Commencement Date.

16.4 In providing the Maintenance Service the Contractor shall -

16.4.1 at his cost, and at no expense to the Employer, provide all labour, consumables, tools required for maintenance work, travelling costs, water sample testing, call-outs, standby provisions and electrical maintenance;

16.4.2 be entitled and obliged to utilise replacement parts from the Employer's Parts Stock provided that the Contractor shall not be entitled to a mark-up or any other compensation in regard to the use of such replacement parts; and

16.4.3 be entitled and obliged to utilise replacement parts other than from the Employer's Parts Stock in which event the Contractor shall be entitled to be reimbursed for such replacement parts so utilised, over and above the Monthly Maintenance Charge, on the basis of the cost to the Contractor of the acquisition of such replacement parts plus the Tender Mark-up thereon.

16.5 For purposes of providing the Maintenance Service, the Employer shall provide the Contractor with the Storage Area, the Marking Area and the Parking indicated by the Contractor in the Tender, failing which as shall be agreed between the Parties and failing such agreement as shall be determined by any independent consulting engineer as shall be appointed by the Employer for such purposes, which determination shall be final and binding on the Parties.

16.6 If in any continuous period of twelve months during this agreement, the Call-Back Rate is NIL, the Employer shall be obliged to pay the Contractor a bonus which is equal to the Monthly Maintenance Charge provided however that such bonus shall not be due and/or payable more frequently than once in any twelve monthly period, the first of which shall commence on the Commencement Date, and the subsequent of which shall commence on each anniversary of the Commencement Date.
17 COMMENCEMENT AND DURATION

17.1 Subject to 18, 19 and 21, this Agreement shall -

17.1.1 commence on the Commencement Date; and

17.1.2 thereafter continue until terminated by either Party in terms of 17.2 or otherwise as provided in this Agreement.

17.2 Either Party may unilaterally terminate this Agreement on the basis that -

17.2.1 such termination shall take effect ninety days after the date upon which a written notice of termination is delivered by any Party to the other;

17.2.2 neither Party shall be entitled to deliver a notice of termination in terms of 17.2.1 prior to the fifth anniversary of the Commencement Date.

18 TERMINATION

Notwithstanding anything to the contrary contained in this Agreement, the Employer shall be entitled to terminate this Agreement summarily by means of written notice of such termination delivered to the Contractor provided that -

18.1 such termination shall take effect on the date of delivery of such termination notice to the Contractor;

18.2 such termination is based upon the fact that -

18.2.1 the Equipment being permanently disconnected from operation;

18.2.2 the Employer ceases for any reason to be the registered owner of the building in which the Equipment is installed;

18.2.3 the Employer decides to replace or modernise the Equipment and the Contractor is not the successful tenderer for the installation of new Equipment or the modernisation thereof; or

18.2.4 the Employer ceases to be responsible for the management function of the building in which the Equipment is installed.

19 SUSPENSION OF MAINTENANCE

19.1 If the tenant occupancy level in the building in which the Equipment has been installed, drops to a level which is commercially insufficient, the Employer shall be entitled to -

19.1.1 de-commission the Equipment either temporarily or permanently on thirty days written notice thereof to the Contractor;

19.1.2 re-commission the Equipment thereafter once more on thirty days’ notice to the Contractor.

19.2 The Maintenance Consideration and the Parties’ respective obligations under this Agreement shall be suspended and not be enforceable during the period of de-commissioning of the Equipment referred to in 19.1, namely from the expiry of the thirty day period from the delivery of the notice in 19.1.1 to expiry of the thirty day period of the delivery of the notice in 19.1.2.

19.3 On being requested to de-commission the Equipment, the Contractor shall undertake, under a separately charged order from the Employer to take such actions as shall be necessary to disconnect the Equipment and preserve the Equipment while non-operational.
19.4 In the event of any Equipment being withdrawn from service, the Contractor shall for the period of its withdrawal assume no responsibility of any nature for the safety of any persons or goods that are in any way affected by the said withdrawal of such Equipment.

19.5 On request by the Employer to re-commission the Equipment, the Contractor shall undertake, under a separately charged order from the Employer, to clean, inspect and report to the Employer any defects which may have occurred during the period the Equipment was not in use, including but not limited to the following: corrosion, malicious damage, water and any other damage to the Equipment.

20 PENALTIES

Without prejudice to the Employer's rights and remedies in terms of 21 below, the Employer shall be entitled to recover (by means of set-off or otherwise) the following penalties from the Contractor as a genuine pre-estimate of the Employer's anticipated damages in the following instances –

20.1 CALL-BACK RATE PENALTY

20.1.1 If the Call-Back Rate exceeds 4 (four) in any twelve month period referred to in 4.6.2, the Employer shall be entitled to recover a penalty from the Contractor equal to 50% of one month's Maintenance Consideration;

20.1.2 If the Call-Back Rate exceeds 6 (six) in any twelve month period referred to in 4.6.2, the Employer shall be entitled to recover a penalty from the Contractor equal to one month's Maintenance Consideration;

20.1.3 If the Call-Back Rate exceeds 8 (eight) in any twelve month period referred to in 4.6.2, the Employer shall be entitled to recover a penalty from the Contractor equal to two month's Maintenance Consideration.

20.2 DOWN-TIME PENALTY

On each occasion on which a Maximum Down-Time is exceeded, the Employer shall be entitled to recover a penalty from the Contractor equal to 10% (ten per centum) of one month's Maintenance Consideration.

20.3 CALL-BACK RESPONSE TIME PENALTY

20.3.1 On each occasion on which a Call-Back Response Time is exceeded, the Employer shall be entitled to recover a penalty from the Contractor equal to 10% (ten per centum) of one month's Maintenance Consideration.

20.3.2 In the event of any Call-Back Response Time being exceeded by 24 hours or more, the Employer shall be entitled, without prejudice to any other rights or remedies it may have in terms of this Agreement, including the rights and/or remedies referred to in 20.3.1 and/or 21 hereof to engage a person other than the Contractor ("Third Party") to rectify any fault in the Equipment or Equipment breakdown on the basis that, in such event, the Employer shall be entitled to claim and recover from the Contractor the reasonable charges to the Employer by the Third Party relative to the corrective maintenance which shall have been applied to the Equipment by such Third Party.

21 BREACH

Should either Party ("Defaulting Party") breach any material provision of this Agreement and fail to remedy such breach within fourteen days of receiving written notice from the other Party ("Aggrieved Party"), then the Aggrieved Party shall be entitled, without prejudice to its other rights in law, including without limitation the right to claim and recover damages in lieu of any penalties stipulated for in this Agreement, to cancel this Agreement by written notice delivered to the Defaulting Party or to claim immediate specific performance of all the Defaulting Party's obligations under this Agreement.

22 SECURITY

The Contractor shall deliver to the Employer, within fourteen days of the Employer's written demand therefor, security to the extent of 25% of the Annual Maintenance Consideration for the due and faithful fulfilment by the Contractor of its obligations under this Agreement on the basis that -
22.1 such security shall be in the form of a Bank Guarantee issued by a Bank or other financial institution approved by the Employer;

22.2 such Bank Guarantee shall, materially conform to the specimen Bank Guarantee attached hereto as Appendix 2;

22.3 the cost of such Bank Guarantee shall be for the account of the Contractor.

23 INSURANCE

23.1 The Contractor shall at its cost and expense be obliged for the duration of this Agreement to effect and maintain the following policies of insurance with insurers which are acceptable to and have received the prior approval of the Employer -

23.1.1 a Contractor's all risk insurance policy and an insurance policy with SASRIA in the joint names of the Employer and the Contractor and its subcontractors which provides indemnity cover for not less than R2 000 000 (two Million Rand) against physical loss of or damage to works which the Contractor shall effect in addition to and/or in respect of the Equipment and materials on site, in connection therewith;

23.1.2 a public liability insurance in the joint names of the Employer, the Contractor and his subcontractors, which provides indemnity cover for not less than R2 000 000 (two Million Rand) and which shall indemnify the Employer, its employees and officials, the Contractor and the Contractor's subcontractors, employees and officials from all claims for the recovery of loss, damage and/or personal injury by any person arising out of the fault of the Contractor or any of its subcontractors employees or officials in connection with the Equipment and/or the provision of the Maintenance Service in terms hereof.

23.2 The Contractor shall forthwith after the Commencement Date deliver to the Employer satisfactory written proof of the existence and validity of the Insurance Policies in 23.1 and the Contractor shall, whenever the premiums became due under such policies of insurance, deliver to the Employer proof of the payment of each of such premiums.

24 ARBITRATION

24.1 Save as in hereinebefore provided, should any dispute at any time arise between any of the Parties in regard to any matter arising out of this Agreement or its interpretation or rectification or termination or cancellation, any Party shall be entitled, by written notice to the other Party, to require that the dispute be referred to arbitration in accordance with this 24.

24.2 The arbitration referred to in 24.1 shall be held -

24.2.1 at Johannesburg;

24.2.2 under the provisions of the Arbitration Act No 42 of 1965, as amended from time to time.

24.3 The arbitrator shall be, if the question of issue is -

24.3.1 primarily an accounting matter, an independent practising accountant agreed upon between the Parties or failing such agreement, an accountant appointed by the President of the South African Institute of Chartered Accountants;

24.3.2 primarily a legal matter, a practising senior counsel of not less than five years standing or practising senior attorney of not less than twenty years standing as agreed upon between the Parties or failing such agreement appointed by the chairman of the Johannesburg Bar Council;

24.3.3 any other matter, an independent person, agreed upon between the Parties or failing such agreement a person appointed by the president for the time being of the South African Institute of Civil Engineers.

24.4 If agreement cannot be reached within seven business days after the arbitration has been demanded as to whether the question in issue falls under 24.3.1, 24.3.2 or 24.3.3, then a practising senior counsel of not less than five years standing as such agreed upon between the Parties, and failing agreement appointed by the Chairman of the Johannesburg Bar Council as soon as possible thereafter, shall be appointed as arbitrator so that an arbitration can be held and concluded, if possible, within the prescribed period of twenty-one business days.
24.5 The Parties irrevocably agree that the decision in those arbitration proceedings -

24.5.1 shall be binding on them;

24.5.2 shall be carried into effect forthwith;

24.5.3 shall, at the request of any one of the Parties, be made an order of any court of competent jurisdiction.

24.6 The arbitrator shall be obliged to give written reasons for his decision.

24.7 Notwithstanding anything to the contrary contained herein, any Party shall in the case of urgency be entitled to seek interim relief from the High Court of South Africa having jurisdiction in respect of Johannesburg, pending a final determination by the arbitrator.

24.8 Notwithstanding the referral of any dispute to arbitration in terms of this clause, all other matters governed by this Agreement shall continue to be so governed.

24.9 This clause shall survive the termination or cancellation of this Agreement for any reason whatsoever.

25 NOTICES

25.1 Each Party chooses as its address for all purposes under this Agreement, ("Chosen Address"), whether for serving any court process or documents, giving any notice, or making any other communications of whatsoever nature and for any other purpose arising from this agreement ("notice") as follows -

25.1.1 Employer - [ ]

Telefacsimile - [ ]

25.1.2 Contractor - [ ]

Telefacsimile - [ ]

25.2 Any notice required or permitted to be given under this Agreement shall be valid and effective only if in writing and shall be addressed to be for the attention of the designated officer of the Party to which it is addressed.

25.3 Any Party may by notice to the other Parties change its chosen address to another physical address in the Republic of South Africa and such change shall take effect on the seventh day after the date of receipt by the Party who last receives the notice.

25.4 Any notice to a Party contained in a correctly addressed envelope and -

25.4.1 sent by prepaid registered post to it at its chosen address; or

25.4.2 delivered by hand to a responsible person during ordinary business hours at its chosen address, shall be deemed to have been received, in the case of 25.4.1, on the tenth business day after posting (unless the contrary is proved) and, in the case of 25.4.2, on the date of delivery.

25.5 Notwithstanding anything to the contrary herein, a written notice actually received by a Party, including a notice sent by telefax ("the first notice"), shall be an adequate notice to it notwithstanding that it was not sent or delivered to its chosen address, provided that, within the next three succeeding business days a copy of the first notice is delivered to the chosen address, accompanied by a notice giving the following particulars -

25.5.1 where the first notice was sent by telefax, the date and time of despatch and the telefax number to which it was sent; and
25.5.2 where the first notice was delivered in a manner other than by telefax, the manner of delivery, the date on which it was delivered, the person by whom it was received and where it was received.

26 GOVERNING LAW

Subject to 24 the law governing this Agreement, including without limitation its interpretation and all disputes arising out of this Agreement, is the law of South Africa, and the Parties submit to the exclusive jurisdiction of the South African courts in respect of any matter arising from or in connection with this Agreement, including its termination. The Parties further consent to the jurisdiction of the High Court of South Africa having jurisdiction in respect of Johannesburg.

27 GENERAL

27.1 This Agreement constitutes the sole record of the agreement between the Parties with regard to the subject matter hereof. No Party shall be bound by any express or implied term, representation, warranty, promise or the like not recorded herein.

27.2 No addition to, variation of, or agreed cancellation of this Agreement shall be of any force or effect unless in writing and signed by or on behalf of the Parties.

27.3 No relaxation or indulgence which any Party may grant to any other shall constitute a waiver of the rights of that Party and shall not preclude that party from exercising any rights which may have arisen in the past or which might arise in future.

27.4 Any provision of this Agreement which contemplates performance or observance subsequent to any termination or expiration of this Agreement shall survive any termination or expiration of this Agreement and continue in full force and effect.

27.5 An approval or consent given by a Party under this Agreement shall not relieve the other Party from responsibility for complying with the requirements of this Agreement nor shall it be construed as a waiver of any rights under this Agreement except as and to the extent otherwise expressly provided in such approval or consent, or elsewhere in this Agreement.

28 EXECUTION

This Agreement has been signed as follows in two originals on behalf of each of the Parties -

28.1 Signed at [ ] on [ ] 20………..

For the Employer who warrants that he is duly authorised hereto

28.2 Signed at [ ] on [ ] 20………..

For the Contractor who warrants that he is duly authorised hereto
## MAINTENANCE AGREEMENT

### MAINTENANCE SCHEDULE FOR: DX SPLIT UNITS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>MONTHLY</th>
<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remove air filters, clean and re-install correctly and ensure that filter frame and media is fitted properly with no by-pass or obstruction.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check and correct condensate drain if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Check condition and operation of thermostat and control.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Check electrical wiring and component condition and operation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Check for correct condenser air path and ensure that unit is free from any re-circulation.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Check condenser fan for operation vibration and noise and correct if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Check evaporator fan for operation, vibration and noise and correct if required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Check compressor for operation, vibration and noise and correct if required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Check cooling cycle.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Check heating cycle.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Check for gas leaks, repair and top-up with refrigerant if required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Check for pipe insulation damage, repair and vapour seal if required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Check safeties.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Check unit and unit casing, clean and position and bracketing.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Check thermostat sensing bulb for position and bracketing.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Clean condenser coil.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>17</td>
<td>Clean evaporator coil.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Clean unit sump.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Clean unit casing and components.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Check air grilles and diffusers for condition, correct position and adjustment.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
### MAINTENANCE AGREEMENT

#### MAINTENANCE SCHEDULE FOR: - ELECTRICAL SWITCH & CONTROL PANELS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>MONTHLY</th>
<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Panels to be cleaned internally.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Terminals to be checked and tightened.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Indicating light globes to be replaced where necessary.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Circuit breakers and fuses to be checked and investigate reasons for any</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>blown fuses or circuit breakers in OFF position rectify faults and replace</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>blown fuses and faulty circuit breakers.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>Starters, contactors and relays to be checked to ensure moving bridges</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>slide freely and that all contact points are clean. Investigate and rectify</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cause of excessive burning of contacts.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>Time set settings to be checked and correctly adjusted if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Thermal overload settings to be checked and reset if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Star Delta timers to be checked and delay timers to be correctly set.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Automatic sequences to be checked and reset if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Electrical heater connections to be checked for correct amperage and</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>faulty elements to be recorded.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Internal wiring to be tidied up and labeling to be checked.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Safety controls to be checked and operation of controls to be tested.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Control thermostats operation to be checked and calibrated if necessary.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>14</td>
<td>Motorized damper, linkages and motors to be checked and operation observed</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>and reset if necessary.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Maintenance Agreement

#### Maintenance Schedule for: Air Distribution Systems

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>MONTHLY</th>
<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check all ducting for abnormal air leaks and seal if required.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Check all flexible duct and canvas connections for deterioration and rectify where required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Check grille, louvers and dampers for deterioration and correct if required.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Check Vermin-screens for cleanliness and deterioration and attend if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Clean grilles and diffusers</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
### Maintenance Schedule for: Motorised Dampers

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>MONTHLY</th>
<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Damper settings and operation to be checked and adjusted if necessary</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PRD’s (only) operation to be checked against command value and static pressure sensor setpoint.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Motorized damper linkages and motors to be checked and operation observed, lubricate and reset if necessary.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Damper motors to be fastened to shaft.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Check all electrical connections and controls, make sure all connections are tight</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
### MAINTENANCE AGREEMENT

#### MAINTENANCE SCHEDULE FOR: BUILDING MANAGEMENT SYSTEMS

<table>
<thead>
<tr>
<th>ITEM</th>
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<th>MONTHLY</th>
<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>FIELD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.</td>
<td>Measure, record and adjust power supply voltages.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.2.</td>
<td>Measure noise levels in transmission lines if needed.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.3.</td>
<td>Check for transmission errors.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.4.</td>
<td>Clean interior of control cubicles.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5.</td>
<td>Check condition and alignment of parts.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6.</td>
<td>Ensure cables are secured.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.7.</td>
<td>Tighten all terminals.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.8.</td>
<td>Calibrate all sensors.</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2.</td>
<td><strong>MANAGEMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1.</td>
<td>Check communication (LED’S).</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2.</td>
<td>Perform BUS communication test.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2.3.</td>
<td>Ensure schedules are as required by client and are programmed.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4.</td>
<td>Back up database.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2.5.</td>
<td>Check for points in Manual mode and reset to auto.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6.</td>
<td>Check and clear alarm faults.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td><strong>FIELD INSTRUMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.</td>
<td><strong>Analog</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.1</td>
<td>Check physical mounting.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.2</td>
<td>Check and calibrate transducer reading to actual reading.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3.1.3</td>
<td>Provide a report on sensors checked – actual to measured value.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.4</td>
<td>Check terminations</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3.1.5</td>
<td>Check actuator strokes and actions and set correct if needed.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.6</td>
<td>Prove the movement and operation of all valves.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td><strong>Digital</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2.1</td>
<td>Activate contacts to ensure signal is detected by system.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2.2</td>
<td>Check calibration of thermostats and pressure switches.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2.3</td>
<td>Prove that the outputs activate the connected electrical equipment (contactor etc.)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2.4</td>
<td>Check physical mounting and electrical connections</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td><strong>Fire</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.1</td>
<td>Check operation of detector using approved method for detector type.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.2</td>
<td>Inspect and periodic test of break glass units/manual call points</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3.3</td>
<td>Verify loop response at end of each loop</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## PART C4.7 MAINTENANCE AGREEMENT

**MAINTENANCE SCHEDULE FOR: - GENERAL**

<table>
<thead>
<tr>
<th>ITEM</th>
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<th>QUARTERLY</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attend to any complaints made by the Client’s Representative.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>While attending to any defects and servicing the plant the Contractor shall</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>not unduly disturb the occupants in the areas concerned.</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Replace all inspection panels and covers and re-fix all screws, bolts and</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td></td>
<td>nuts and replace if necessary.</td>
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<td></td>
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</tr>
<tr>
<td>4</td>
<td>Clean all plant and equipment and record and report dirty plant condition</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>to correct authority.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lock switch panels and plant rooms and return keys to proper authority.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sign log book and enter details where required.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Acknowledgement of service and report to be completed and signed by</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Client’s Representative. Report on remedial work undertaken and on any</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>faults found and replacements and repairs required.</td>
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</table>

### NOTES:

- A copy of each such acknowledgement of service and report to be submitted to the Client by the Contractor within 7 days of each service.
- Air conditioning plants shall never be operated with any safety or overload protection device bridged out.
- When power is initially switched on, after being off or disconnected for more than one hour, the compressors should not be operated for a further period of two hours.
### MAINTENANCE AGREEMENT

MAINTENANCE SCHEDULE FOR: - MEDIUM AND LARGE FANS

**AXIAL FLOW AND LARGE PROP FANS**

<table>
<thead>
<tr>
<th>ITEM</th>
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<th>QUARTERLY</th>
<th>ANNUALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check fan drive, shaft, bearings, couplings, pulleys, impeller/blades, all moving parts, etc. for alignment, lubrication and wear and tear and adjust or rectify if required.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check fan impeller/blades, casing, mounting, etc. for deterioration and dirt deposits, clean, rust proof, treat and repair if necessary.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Check fan and motor for abnormal noise and vibration and rectify if necessary.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Check fan and motor for abnormal temperature and bearing condition and rectify if necessary.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Check fan and motor mountings and bracketing for condition and rigidity.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Check motor electrical connections and wiring for loose and hot connections, damaged insulation and short-circuiting and repair if required.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Check circuit breakers, starter, overloads and all other electrical and control components for condition and operation.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Check for short-circuiting of air or airflow obstruction and attend if necessary.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>